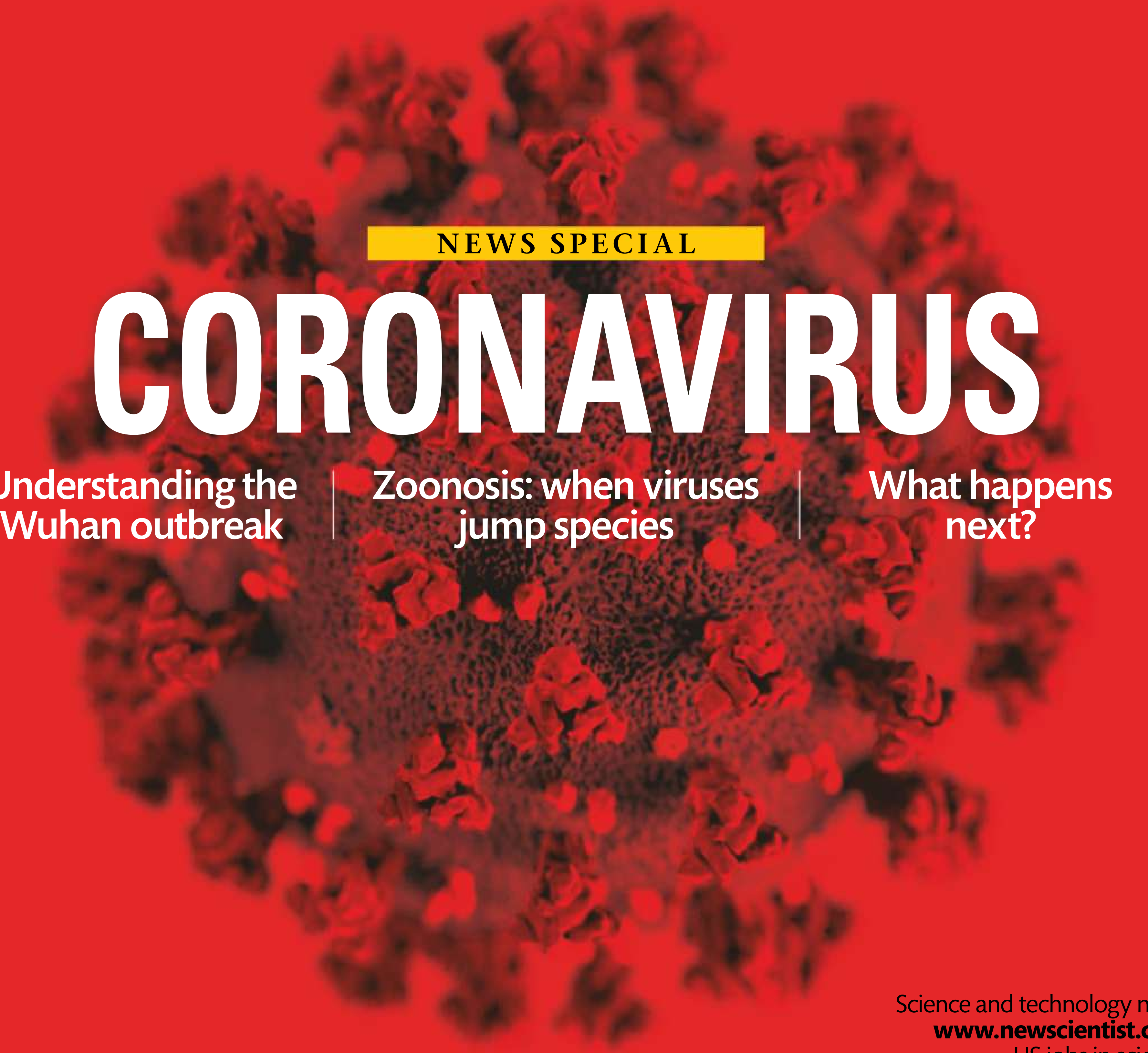
New Scientist

WEEKLY February 8-14, 2020

SPIDER CONSCIOUSNESS
Inside the amazing mind of an arachnid

QUANTUM FREEZE
Nanoparticle cooled to nearly absolute zero

SANITY CHECK
The flawed experiment that shook psychiatry to its core



NEWS SPECIAL

CORONAVIRUS

Understanding the Wuhan outbreak | Zoonosis: when viruses jump species | What happens next?

Science and technology news
www.newscientist.com
US jobs in science
No3268 US$6.99 CAN$7.99

FIRST ALPHABET
Untold story of a writing revolution

PLUS SINKING SEABED / **ROBOTS THAT SWEAT** / LOCUST PLAGUE / **WIKI'S MISSING WOMEN** / CLOSE-UP OF THE SUN'S SURFACE

Subscription offer

New Scientist can...

...help make you fitter

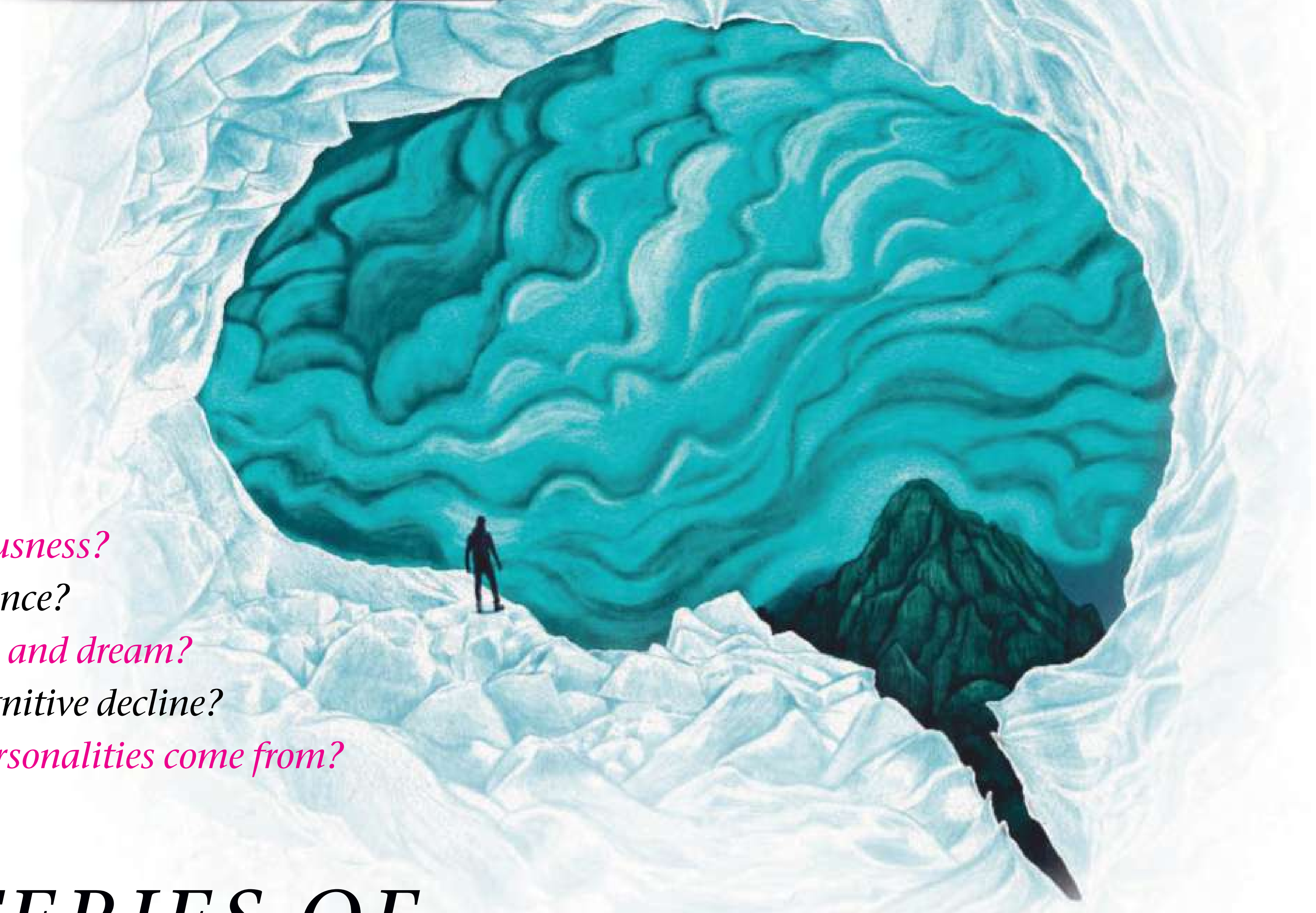
Whether you want to get fitter, live healthier, change your perspective or just spark some winning conversation, *New Scientist* can help you week in week out.

Subscribe and receive a FREE copy of our latest release, *This Book Could Save Your Life* – the ultimate scientific guide to living a longer, healthier life without faddy diets and unproven exercise crazes.

Get started by visiting
newscientist.com/14154
Or call 1 888 822 3242, quoting reference 14154

NewScientist
Know more. *Live better*

Free book available while stocks
last. Only in specific countries



What is consciousness?
What is intelligence?
Why do we sleep and dream?
What causes cognitive decline?
Where do our personalities come from?
and many more

MYSTERIES OF
THE HUMAN BRAIN

Explore the intricacies of the most complex object in the known universe with the latest issue of New Scientist: The Collection

Buy your copy from all good
magazine retailers or digitally.

ANDROID APP ON Google play

Download on the App Store

This week's issue

On the cover

7 Coronavirus
Understanding the Wuhan outbreak
Zoonosis: when viruses jump species
What happens next?

34 First alphabet
Untold story of a writing revolution

Vol 245 No 3268
Cover image: CDC/Alissa Eckert, MS. Dan Higgins, MAM

42 Spider consciousness
Inside the amazing mind of an arachnid

16 Quantum freeze
Nanoparticle cooled to nearly absolute zero

38 Sanity check
The flawed experiment that shook psychiatry to its core

12 Sinking seabed 14 Robots that sweat 28 Locust plague 46 Wiki's missing women 18 Close-up of the sun's surface

New Scientist events

Instant Expert: Human Evolution
Join six expert speakers in London on 29 February for a one-day masterclass. Find out more at **newscientist.com/events**

News

14 SpaceX Starlink
Astronomers want to sue to protect the night sky

15 Smells like teen vaping?
Why concerns over e-cigarette use may be overblown

20 Nuclear winter
Nuclear power was meant to save us from climate change, but it is on the way out

Views

23 Comment
Andrew Barron on the evolution of sexuality

24 The columnist
Graham Lawton on why aiming for net zero could work

26 Letters
Ask an AI to explain how an AI made a decision

28 Aperture
A swarm of locusts flies through Kenya eating crops

30 Culture
How to fight back against everyday racism

LEFT: CFKAM/GETTY IMAGES; ABOVE: SHUTTERSTOCK

42 Spider intelligence The remarkable abilities of arachnids

23 Comment

> "Sexuality could be influenced by hundreds of genes and there is no single gene for same-sex attraction"

Features

34 First alphabet
Meet the inventors of our ABCs

38 Sanity check
Inside the iconic experiment that devastated psychiatry

42 Spider consciousness
Arachnid intelligence is more sophisticated than we thought

46 Wiki's missing women
Why Jess Wade is writing history

The back pages

51 Science of cooking
How to temper chocolate

52 Puzzles
A quick crossword, a beetle problem and the quick quiz

53 Feedback
Joy of the rovers and a puzzle puzzle: the week in weird

54 *Almost* the last word
How can you get flu after vaccination? Readers explain

56 The Q&A
Psychologist Suzi Gage on saying why to drugs

NewScientist

SECOND EDITION OF
BEING HUMAN

BEING
HUMAN

Take a step back from the everyday chores of being human to tackle the big – and small – questions about our nature, behaviour and existence.

Buy your copy from all good magazine retailers or digitally.
Find out more at **newscientist.com/TheCollection**

ANDROID APP ON Google play

Download on the App Store

Deadly unknowns

We are still scrambling to understand how dangerous the Wuhan coronavirus is

FOR those of us who turn to science for answers, the Wuhan coronavirus outbreak is unsettling. We don't know what proportion of infected people are likely to die (see page 9); our figures for how many other people on average each carrier infects are only estimates; and the total number of cases is likely to be far higher than those confirmed so far. These three parameters are crucial for epidemiologists who use models to calculate how bad an outbreak will get, but we don't yet know what values to punch into the models.

As cases in China soar, the list of unknowns gets even longer. It remains unclear whether the virus can spread before symptoms show. We don't yet know how or when the virus is likely to have crossed over from bats (see page 10), or why the first known human case of the virus seems to have no connection to the Wuhan food market where the outbreak appears to have begun. Is every case equally infectious, or are some people unlikely to pass it on, while others act as super-spreaders? And is the virus only deadly for those who are older or who already have chronic conditions?

> "If the virus goes global, it could one day resemble flu, which every year causes hundreds of thousands of deaths"

What we do know is that the outbreak is likely to go one of three ways (see page 8). As this magazine went to press, the outbreak seemed on the verge of becoming a pandemic – in which multiple epidemics of an infection take place across the world. From here, the virus may either peter out or go truly global. We can't know yet how many lives this would claim.

If it goes global, it could one day resemble flu, which every year causes an estimated 3 to 5 million cases of severe illness, and about 290,000 to 650,000 deaths. Flu can cause mild symptoms in some people and much worse ones in others, and most deaths occur in people over the age of 65 – all of which may be true for the new coronavirus.

There is another option. The race is now on to find drugs and vaccines that could help bring the virus under control and prevent global exposure. While drug development will take time, trials of existing drugs are already under way in China (see page 11). If successful, we may be able to save many lives – although we can't yet calculate the number. ■

NewScientist

PUBLISHING & COMMERCIAL

Display advertising
Tel +44 (0)20 7611 1291 **Email** displayads@newscientist.com
Commercial director Chris Martin
Display sales manager Justin Viljoen
Lynne Garcia, Bethany Stuart, Henry Vowden,
(ANZ) Richard Holliman
Recruitment advertising
Tel +44 (0)20 7611 1204 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Deepak Wagjiani, (US) Jeanne Shapiro
New Scientist Live
Tel +44 (0)20 7611 1245 **Email** live@newscientist.com
Events director Adrian Newton
Creative director Valerie Jamieson
Event manager Henry Gomm
Sales director Jacqui McCarron
Exhibition sales manager Rosie Bolam
Marketing manager Katie Cappella
Events team support manager Rose Garton
Marketing executive Jessica Lazenby-Murphy
New Scientist Discovery Tours
Director Kevin Currie
Marketing
Head of campaign marketing James Nicholson
Digital marketing manager Poppy Lepora
Head of customer experience Emma Robinson
Email/CRM manager Rose Broomes
Head of data analytics Tom Tiner
Web development
Maria Moreno Garrido, Tom McQuillan, Amardeep Sian
Piotr Walkow

© 2020 New Scientist Ltd, England. New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist Ltd, England. New Scientist (Online) ISSN 2059 5387. New Scientist Limited, 387 Park Avenue South, New York, NY 10016

Periodicals postage paid at New York, NY and other mailing offices
Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA.
Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055

MANAGEMENT

Chief executive Nina Wright
Finance director Amee Dixon
Chief technology officer Chris Corderoy
Marketing director Jo Adams
Human resources Shirley Spencer
HR coordinator Serena Robinson
Facilities manager Ricci Welch
Executive assistant Lorraine Lodge
Receptionist Alice Catling

Non-exec chair Bernard Gray
Senior non-exec director Louise Rogers

CONTACT US

newscientist.com/contact
General & media enquiries
US **Tel** +1 617 283 3213
PO Box 80247, Portland, OR 97280
UK **Tel** +44 (0)20 7611 1200
25 Bedford Street, London WC2E 9ES
Australia 418A Elizabeth St, Surry Hills, NSW 2010
US Newsstand
Tel +1 973 909 5819
Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054
Syndication
Tribune Content Agency
Tel 1-800-346-8798 **Email** tca-articlesales@tribpub.com
Subscriptions
newscientist.com/subscribe
Tel 1 888 822 3242
Email newscientist.na.subs@quadrantsubs.com
Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

EDITORIAL

Editor Emily Wilson
Executive editor Richard Webb
Creative director Craig Mackie
News
News editor Penny Sarchet
Editors Lilian Anekwe, Jacob Aron, Chelsea Whyte
Reporters (UK) Jessica Hamzelou, Michael Le Page, Donna Lu, Adam Vaughan, Clare Wilson
(US) Leah Crane
(Aus) Alice Klein
Interns Gege Li, Layal Liverpool, Jason Arunn Murugesu
Digital
Digital editor Conrad Quilty-Harper
Podcast editor Rowan Hooper
Web team Anne Marie Conlon, David Stock, Sam Wong
Features
Head of features Catherine de Lange and Tiffany O'Callaghan
Editors Gilead Amit, Julia Brown, Daniel Cossins, Kate Douglas, Alison George
Feature writer Graham Lawton
Culture and Community
Comment and culture editor Timothy Revell
Editors Liz Else, Mike Holderness, Simon Ings
Education editor Joshua Howgego
Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Chris Simms, Jon White
Design
Art editor Kathryn Brazier
Joe Hetzel, Dave Johnston, Ryan Wills
Picture desk
Tim Boddy
Production
Production manager Alan Blagrove
Robin Burton, Melanie Green

Discover a world of books and more for the scientifically minded

Come in, we're
OPEN
Ne
W
Sc
THE NEW SCIENTIST
NewScientist THE COLLECTION
THE QUEST FOR SPACE
HOW WE REACHED THE MOON...
NewScientist INSTANT EXPERT
NewScientist
WHY DO BOYS HAVE NIPPLES?
AND 73 OTHER WEIRD QUESTIONS THAT ONLY SCIENCE CAN ANSWER
THIS BOOK COULD SAVE YOUR LIFE
NewScientist
THIS BOOK COULD SAVE YOUR LIFE
THIS BOOK WILL BLOW YOUR MIND
NewScientist
SCIENCE IS MY CUP OF TEA_
CHILLY'S
New Scientist

New Scientist
Online Shop

shop.newscientist.com

STR/AFP VIA GETTY IMAGES

A recently discharged patient is sprayed with disinfectant in Wuhan

Inside Wuhan's lockdown

Hubei residents are trying to stay positive as hospitals attempt to treat thousands infected by the new coronavirus, reports **Donna Lu**

THE streets of Wuhan in Hubei province are eerily quiet. The city of 11 million people, the centre of the coronavirus outbreak, has been locked down since 23 January, with all public transport, flights and trains suspended.

"You pretty much don't see anybody outside," says a man who lives in Wuhan and asked to be identified only as Alex. Private vehicles are banned in the downtown area. Highways are shut so residents aren't able to leave the city. The only places full of people are pharmacies, where queues await those trying to buy face masks, gloves and alcohol disinfectant.

Despite concerns about potential food shortages, large supermarkets remain open and well stocked. Some stores won't allow customers in without a body temperature scan.

Following the outbreak, the Lunar New Year holiday – which was supposed to end on 30 January – has been extended across China. In Hubei, businesses will be shut until at least 13 February.

Alex doesn't know when he will return to work. "Every day we're at home, closely following the news," he says. The first few days of isolation were boring, he says, and now supplies of items like face masks are running short. Alex considers himself lucky because none of his relatives have been infected to date. But friends and colleagues have been.

It has been estimated that at least 75,000 people in Wuhan have been infected with the 2019-nCoV virus (*The Lancet*, doi.org/ggjvr7). Thousands of medical staff from across China have been sent to Wuhan. A nurse from Anhui province, who didn't want to be identified, says the 200-bed hospital in Wuhan where she is working is at capacity. Staff are supposed to work 4-hour shifts, but they often last 6 to 8 hours, she says. She adds that protective suits and sterilisation equipment were in extremely short supply until 1 February, when more donations arrived.

A doctor working in Shanghai who asked to be identified only as Ryan estimates that 50 staff from his hospital have already been sent to Wuhan to help treat patients.

The remaining medical staff at his hospital don't have enough masks, he says, because most of them have been donated to Wuhan. They have resorted to reusing masks after irradiating them under UV light and have suspended all but essential medical services.

Wuhan hospitals have been overwhelmed, with many patients sent home to self-quarantine. Hospitals are being constructed to meet the demand, including the 1000-bed Huoshenshan Hospital, which was built in 10 days and completed on 3 February, and the 1300-bed Leishenshan Hospital, which is slated to open on 6 February.

People across China have donated medical supplies, but there has been widespread anger about their distribution. A report from the Hubei Red Cross revealed it had delivered only 200,000 of 2 million donated face masks, many to hospitals that didn't need them.

As lockdowns continue in more than 15 cities in Hubei, residents are trying to keep their spirits up. Across Wuhan, the morale-boosting chant *Wuhan jiāyóu*! (which means "come on" or "stay strong") has echoed out from apartment windows. People have coined the term *yún chī fàn*, which means "meal by cloud", as they virtually eat together via video calls. There is also *yún bài nián* – the same concept for Lunar New Year greetings.

But the uncertainty of when the outbreak will be contained is also taking its toll. "It's hard to stay positive," says Alex. "We're doing our best not to be too anxious." ▮

More coronavirus online

For the latest science on the outbreak, visit newscientist.com/subject/health

Understanding the outbreak

What happens next?

The novel coronavirus that emerged in Wuhan has exploded worldwide. What happens if it goes pandemic? **Debora MacKenzie** reports

WITH more than 17,000 confirmed cases – and probably far more undiagnosed – the 2019-nCoV coronavirus that emerged in Wuhan, China, seems poised to go global. As *New Scientist* went to press, the epidemic was still centred on the province of Hubei, but the virus had travelled to 23 countries, and further epidemics seemed possible.

Genetic analysis suggests that the virus isn't changing much in humans, becoming neither more nor less harmful. So where is the outbreak likely to go from here?

There are three options, says Eric Toner at Johns Hopkins University in Baltimore. One, viruses new to humans that don't adapt quickly can simply peter out after they have spread to several successive people, as another coronavirus from animals, MERS, seems to. But the rocketing number of cases in China mean 2019-nCoV shows no sign of doing this.

Two, we could block transmission of the virus enough for it to die out. One way would be with drugs or vaccines (see "How soon will a treatment be ready?", page 11), but it may take a year to develop anything effective. Or we could quarantine infected people and block the virus. That worked for the related SARS virus in 2003, but early signs suggest that it might not be so easy this time.

Global spread

"Options one and two seem unlikely," says Toner. Instead, the virus may simply spread, like flu does, until most people have been exposed to it and either died or recovered and become immune. Then it may burn out for lack of hosts, or become a disease that mostly affects children who haven't yet encountered it.

Case numbers

Confirmed cases as of 3 February – but there are likely many more undiagnosed cases in China

GLOBALLY

17,391 confirmed

CHINA

17,238 confirmed

2296 severe

361 deaths

OUTSIDE CHINA

153 confirmed

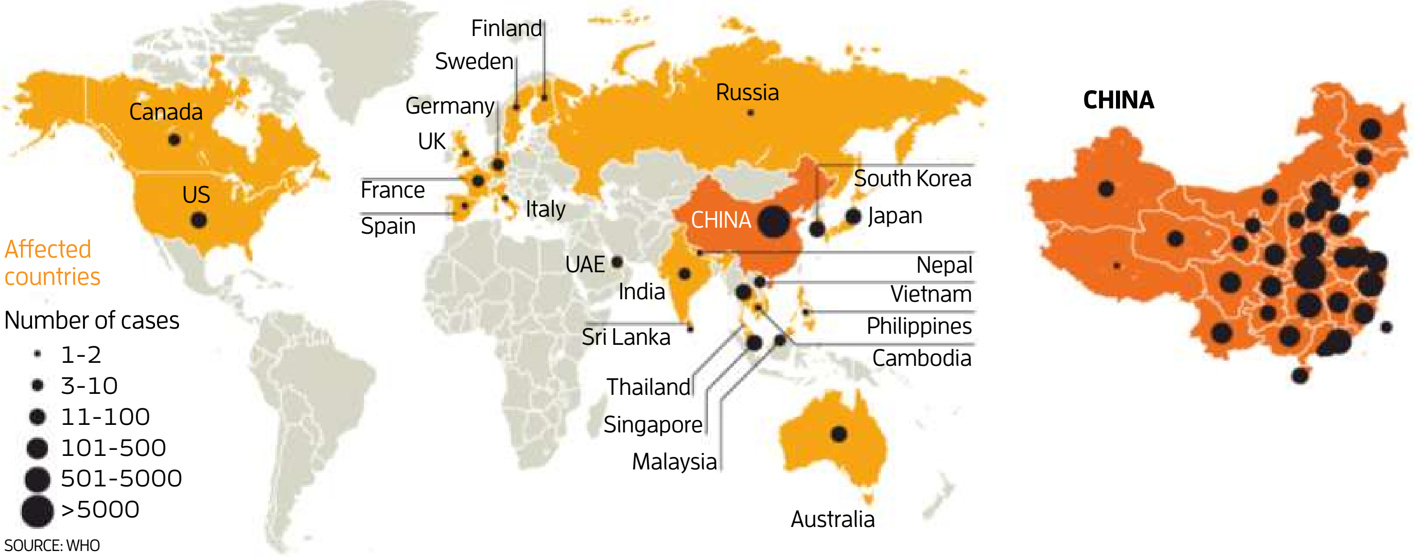
23 countries

1 death

SOURCE: WHO

The coronavirus's spread

As of 3 February, the vast majority of cases clustered around China's Hubei province and surrounding regions



SOURCE: WHO

Last year, Toner led a pandemic management exercise in Baltimore, in which industry and health leaders discussed options as a computer model of a pandemic involving a fictional coronavirus played out. After 18 months, the spread of the virus started to slow down, as people either died or became immune. However, by then, the fictional virus had killed 65 million people.

Toner stresses that the simulation was just that: a model of a hypothetical virus slightly different to 2019-nCoV. But unless the new virus self-destructs or we find ways to stop it, it is likely to follow a similar route, circulating until the pandemic slows.

This is especially bad news for older people and those with pre-existing health conditions. Like SARS, the virus seems to kill by triggering out-of-control inflammation. In China, people with severe cases of the virus are more likely to be older or have chronic inflammatory diseases like diabetes, says Sylvie Briand at the World Health Organization (WHO).

The full impact of the virus will depend on its death rate, which we don't yet know (see "Understanding the Wuhan virus", right). It seems to spread more readily than SARS, making it harder to contain with quarantine.

One problem is that some cases of the new virus are mild. No public health systems are equipped to test everyone with flu-like symptoms, then quarantine all those who have the virus – and everyone they have been in contact with – to prevent spread. However, this is what we would need to do to stop it spreading, says David Heymann at the London School of Hygiene and Tropical Medicine, who organised the WHO's SARS campaign.

Preparedness plans

In theory, the virus could be largely kept out of other countries and burn out in China. But that would be hard: models show that even testing all travellers at exit and entry would fail to catch 75 per cent of those incubating the virus, says Pasi Penttinen at the European Centre for

FEATURE CHINA/BARCROFT MEDIA VIA GETTY IMAGES

A 2000-bed mobile hospital is set up in an exhibition centre in Wuhan, China

Disease Prevention and Control. Temperature monitoring in airports had no effect on SARS.

It therefore seems likely that the virus will go pandemic, circulating in multiple cities worldwide. “Independent self-sustaining outbreaks in major cities globally could become inevitable because of substantial exportation of pre-symptomatic cases,” Gabriel Leung at Hong Kong University and colleagues wrote in a recent modelling study (*The Lancet*, doi.org/ggjvr7). “Preparedness plans and mitigation interventions should be readied for quick deployment globally.”

> **“The virus may spread until most people have been exposed to it and either died or recovered”**

Countries were supposed to invest in such plans under 2005 WHO rules. But an independent report last year found “severe weaknesses in [countries’] abilities to prevent, detect, and respond to health emergencies”. Fewer than 5 per cent of countries got high marks for their ability to rapidly respond to an epidemic.

Heymann says one lucky break with SARS was that it never invaded a chaotic, impoverished megacity, which would have had particular trouble organising the contact tracing and quarantine required to stop a virus this way.

That break seems unlikely with the Wuhan virus, which has already reached India and the Philippines. The Gates Foundation has earmarked $10 million to fight the virus – half for China, the rest to help African countries prepare. African health agencies will hold a workshop in Senegal this week.

Even if the virus remains largely in China, there would be global consequences. According to Michael Osterholm at the University of Minnesota and his team, 153 crucial drugs, from blood pressure pills to stroke treatment, are mostly made in China, and there are fears the virus could affect their production and export.

Osterholm is worried about further impacts. So far, he says, “people aren’t saying how bad it can get”. ▮

Epidemiology

Understanding the Wuhan virus

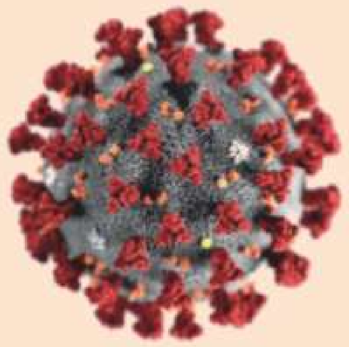
Debora MacKenzie

Pathogens obey simple rules of transmission, and these can be used to predict how fast the number of infections will rise and fall, how hard it will be to stop a disease and how bad things are likely to get.

Measuring the necessary parameters in a virus that is new to humans can be difficult, though. First you need the basic reproduction number, R0.

If everyone is susceptible to an infection – and we are, as the Wuhan virus is new to humans – R0 is the average number of other people that any individual with the virus will infect. Research teams have calculated 12 different estimates for the virus’s R0 so far. Together, these suggest it is between 1.8 and 3.3.

To stop an epidemic, the average number of new people that each case infects needs to be below one. This can happen as people become immune, get a vaccine or change their behaviour to prevent transmission. In the case of the Wuhan virus, people in China are already avoiding crowds and public transport.



An illustration of the structure of the new coronavirus

CDC/ALISSA ECKERT, MS; DAN HIGGINS, MAM

The second parameter is the number of cases. Because the illness looks like flu and can be mild, many cases are thought to be going undiagnosed.

But long-distance travellers are coming under close scrutiny, and assuming that they aren’t vastly more likely to be infected than people who don’t travel, this can give us an indication of case numbers. In this way, two research groups have calculated that case numbers in Wuhan could be between 10 and 40 times higher than official numbers.

When a virus has jumped over from animals, as in the case of this coronavirus, one question is whether it is still jumping. So far, analysis suggests very little genetic variation in the virus, which implies it has only crossed into humans once.

Genetic analysis also suggests that the virus appears to be stable: it doesn’t seem to be changing or adapting to us.

Another crucial parameter is the fatality rate, which we cannot yet know. The number of deaths so far make up about 2 per cent of all known cases. But according to the China National Health Commission, only 5 per cent of known cases have either died or recovered so far. Some of the rest will die, so the real death rate must be higher.

One study of hospitalised people with a known outcome suggests that the fatality rate has been 14 per cent, but these are only cases that were severe enough to be hospitalised – we don’t know how many people had milder illness and lower death rates from the virus.

To fill these gaps in our understanding will take massive testing of exposed populations. ▮

Zoonosis

Viruses from animals

Infections that cross over from other species are a deadly problem

Michael Le Page

THE new coronavirus is the latest example of a disease that jumped from animals into humans. When infections do this they can be deadly – and 2019-nCoV is no exception.

Nearly all viruses and bacteria that infect other organisms are completely harmless to people. But a tiny proportion can infect us and cause so-called zoonotic diseases, which come from animals rather than other people.

> **"Zoonotic diseases can be so deadly because we have no pre-existing immunity to them"**

Such diseases are a massive problem. They make around 2.5 billion people ill every year and kill 2.7 million, according to a 2012 estimate. Not all zoonotic diseases cause serious illnesses, but the Ebola virus, for example, currently kills most of those it infects.

One reason zoonotic viruses can be this deadly is that we lack pre-existing immunity to them. Another is that these viruses aren't adapted to humans. Viruses that normally circulate among people can evolve to become less lethal, as this helps them spread. "They don't want you to drop dead within a day because you won't pass it to anyone else," says Chris Coleman at the University of Nottingham, UK.

To get infected, people need to come into contact with the animal the virus usually infects. This is most likely with domesticated animals. Camels carry the MERS coronavirus that causes sporadic human cases, for instance.

Many viruses that jump into people, like MERS, seldom spread from person to person. They can still infect thousands, though: rabies is mostly passed on by dog bites, but kills 60,000 people a year. Others, such as Ebola, can spread from person to person, but aren't very good at it and so cause relatively small outbreaks.

The 2019 coronavirus, by contrast, appears quite good at spreading from person to person. While we don't know how deadly it is yet, Coleman says "it's not the most deadly coronavirus we've ever had".

To trace the new virus's origins, researchers have been comparing its genome to that of other coronaviruses. This showed that it derives from a strain that infects bats, possibly the intermediate horseshoe bat (*Nature*, doi.org/ggj5cg). "It's highly related to bat coronaviruses," says Vaithilingaraja Arumugaswami at the University of California, Los Angeles.

This makes sense as bats are known to harbour many viruses, including coronaviruses. Viral infections are especially likely to spread among bats as they can fly long distances and roost close to each other. Bats also seem able to carry infections without getting ill, which helps spread the viruses.

FLETCHER & BAYLIS/SCIENCE PHOTO LIBRARY

The new virus may have come from intermediate horseshoe bats (*Rhinolophus affinis*)

The new coronavirus might have jumped from bats into another animal a few months or even a few decades ago, and then from that intermediate host into humans. We know that the coronavirus behind the SARS outbreak of 2002 to 2003 spread from bats into palm civets before infecting people.

One initial study suggested the new virus could have come from snakes, but some biologists are sceptical. Another early study implicated mink. Samples from animals at the Wuhan market where the virus appears to have emerged are being tested, but no results have been announced.

It took years to trace the origins of SARS, but technology has greatly improved since then. In the meantime, some charities have called for the permanent closure of markets in China selling wild animals. But this could lead to a more dangerous black market trade. When China shut bird markets in 2013 and 2014 to try to stop H7N9 bird flu spreading, it made things worse.

Coleman thinks there is little we can do to stop people coming into contact with animals that may carry dangerous viruses. "It's very difficult to control that," he says.

Instead, he says we need to have vaccines ready in advance. This could mean creating vaccines that are effective against a wide range of viruses or developing vaccines that require only minor tweaks to work against a new viral strain, much like annual flu vaccines. ▮

Other infections that have jumped to humans

Biologists have been warning for decades about the risks of animal viruses spreading to people, and calling for more surveillance and preparation.

There is good reason to worry. The last global pandemic, the 2009 flu that killed up to 400,000 people, was caused by a strain of flu that came from pigs. And that flu is thought to be a descendant of the 1918 flu, which came from birds and which killed up to 50 million people.

HIV, which has infected about 75 million people, is now thought of as a human virus. But it jumped from chimpanzees into humans relatively recently, in the 1930s.

There are already around four human coronaviruses, which usually cause mild, cold-like symptoms. They are thought to have come from animals thousands of years ago.

Flu remains one of the biggest dangers, with fears that a very deadly strain could emerge. Other zoonotic threats include Lassa fever, Rift Valley fever, Marburg virus disease and Nipah virus infection.

The race for treatments It will take time to develop a coronavirus vaccine, but some existing drugs may help save lives before then, says **Michael Le Page**

THE race to develop vaccines and treatments for the new coronavirus is on. The UK announced this week that it will donate £20 million for vaccine development, while Jack Ma, the billionaire co-founder of Alibaba Group, is giving $14 million to similar efforts.

A vaccine could be essential for controlling the outbreak. There are plans to test an existing experimental vaccine against SARS for use with 2019-nCoV, as well as several efforts to develop new ones, but this will take time. "A vaccine would take at least a year, if not more," says virologist Jonathan Ball at the University of Nottingham, UK.

What can be done in the meantime? The good news is that a few existing drugs might help to save lives before then, and it may be possible to develop other treatments in as little as six months.

There are two main ways of treating viral infections: antibodies or small-molecule drugs. Antibodies are large proteins that bind to viruses and trigger their destruction. It can take our immune systems two weeks after a new infection to produce enough antibodies to fight it off. But this can be accelerated by injecting people with antibodies made by cells grown in a vat. This can keep viruses in check until your immune response kicks in fully.

Antibodies are less likely to cause side effects than other drugs, because they bind more specifically to viruses. This means we should be able to find safe and effective antibodies against the 2019 coronavirus very quickly – the problem will be mass-producing them fast enough.

A team in China that tested antibodies against the coronavirus that caused the SARS outbreak in 2003 has found one that binds to the new coronavirus as well. But team leader Tianlei Ying at Fudan University says it could take one or two months to make enough of the antibody to start testing it in animals and then people.

Antibody search

Two antibodies for treating the MERS coronavirus have already been tested in people. The US biotechnology company that makes them, Regeneron, says they are unlikely to work against the 2019 coronavirus, but it will test them and others.

However, this takes time. While developing antibodies for Ebola, it took Regeneron six months to get to the stage of testing in humans.

A Chinese company called WuXi Biologics announced in a press release last week that it is establishing a 100-strong team dedicated to developing antibody treatments for the 2019 coronavirus. It says it might be able to start mass production in a record four or five months.

By that stage, the outbreak could be over or millions of people might be infected, in which case making enough wouldn't be easy. There aren't many antibody factories, says Ball, and they are all already busy producing antibodies for treating cancer and other diseases.

There might be a shortcut. Instead of making antibodies in a vat, a US company called RenBio injects the genes coding for them into leg muscles. Antibody production in the body continues for weeks or even months, so these injections could be given to people to prevent infections as well as to treat those who are already infected.

"Both are possibilities," says Neal Padte, the head of RenBio. But this has only been tested in other animals, so health authorities may be reluctant to try it in people.

The second way of treating viral infections is to find small molecules that stop viruses replicating by interfering with their proteins.

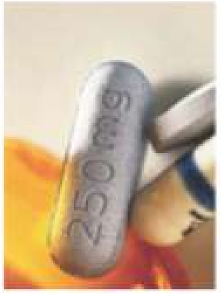
Antivirals like these are usually simple to manufacture, and can be taken in pill form, both of which are big advantages. But 99 per cent of potential small-molecule drugs fail, says Ball. So developing new antivirals from scratch could take years.

> **"Given the scale of the outbreak, you'd hope to quickly discover if these interventions work"**

TPG/ZUMA PRESS/PA IMAGES

Medical workers in Wuhan, China, on 3 February

However, there are a few existing small-molecule drugs that might help. For instance, an experimental antiviral called galidesivir developed for treating Ebola is active against coronaviruses, says its US maker, BioCryst Pharmaceuticals. It has already passed safety tests in people. A team in China has identified four existing, approved drugs that might also work: prulifloxacin, bictegravir, nelfinavir and tegobuvir (bioRxiv, doi.org/dk2z).



FRANCIS SHEEHAN/SPL

Some drugs used to treat HIV may also target coronaviruses

Most promisingly, doctors in Wuhan, China, have already started two randomised controlled trials. One will test two drugs called lopinavir and ritonavir given together. These are already used to treat HIV, and there is some evidence they work against coronaviruses too. The other trial is of an experimental drug called remdesivir, made by US firm Gilead Sciences.

"Given the scale of the outbreak in China, you would hope to get a reasonably quick answer to whether these interventions work," says Ball. "The manufacturing for these is already in place and they are easily available."

In the meantime, most people with the new virus are being treated for their symptoms, rather than the specific virus. Unfortunately, this isn't always enough for people who are older or have pre-existing conditions, for whom the virus seems to be more deadly. ■

Genetics

Privacy of genetic research volunteers may be at risk

Becca Muir

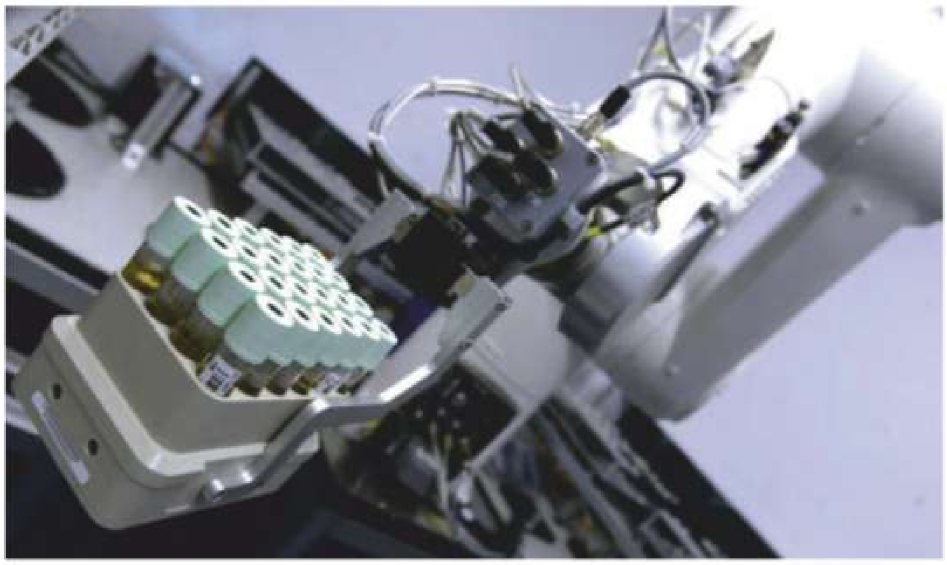
THE privacy of people who add their DNA to research databases may be vulnerable to hackers, who could exploit the information published in genome studies to identify an individual's genetic code.

Genetics researchers are inadvertently publishing information that can theoretically be pieced together to identify someone's DNA held in a research or commercial database, say Daphne Ezer at the Alan Turing Institute in London and her colleagues. Her team simulated how attackers could identify a person's genetic code, and used this method to find a single dog's genetic material in a DNA database.

Genome-wide association studies (GWAS) identify genes that are associated with personal traits or disease. Researchers use large databases containing the DNA of hundreds of thousands of people to conduct these studies and detect subtle DNA differences between participants.

Ezer's team showed how, under some circumstances, a hacker could use the information about an individual's traits published in GWAS to recover that person's genetic information – known as a reconstruction attack.

"You might even be able to identify an individual with just two studies performed on the same database, if a small number of people are included in one study but not another," says Ezer. This could happen if, for example, some participants skip a survey question or join one study later than the other, which Ezer's team describe as a "potentially common" scenario.



GETTY/BLOOMBERG

Blood samples are analysed to produce DNA data for genome studies

In these cases, attackers can use algorithms to predict the genetic details of an individual in one of the studies by combining information from both. The team showed this is possible by finding the genetic information of a single dog in the Cornell Dog Genome database (bioRxiv, doi.org/dkx4).

To protect volunteers' genetic privacy when publishing the results of a study, the team suggests that researchers try scrambling the data to make it noisier, or conceal some identifiable information.

Because the study involved dogs, we don't know if a similar attack would identify people from their genetic information. But if used with the technique that exposed a potential vulnerability in the genealogy testing website GEDMatch in October 2019, "it could potentially be used to reveal the identities of individual participants", says David Baranger, a neurogenetics researcher at the University of Pittsburgh in Pennsylvania.

The UK Biobank, which holds 500,000 genomes in its database, says researchers are prohibited from trying to identify a participant in this way. "We are not aware of any such incident where this has occurred," says a spokesperson.

"Researchers treat the privacy of participants in projects such as the UK Biobank very seriously," says David Curtis at University College London. ▮

Environment

The seabed is slowly sinking but it won't stop sea level rise

THE weight of water from melting ice caps is causing the seabed to sink about 0.1 millimetres a year.

"Greenland and Antarctica are melting much faster [than they were previously], so we can expect much higher ocean deformation in the future," says Bramha Dutt Vishwakarma at the University of Bristol in the UK.

He and his colleagues calculated how much the extra mass in the ocean is pushing down the sea floor, and what this means for sea levels. They found that it will have only a tiny effect on future sea level rise because the oceans are rising about 3 millimetres per year – far faster than the seabed is sinking (*Geophysical Research Letters*, doi.org/dkvv).

Sea level rise is due to climate change, which is in turn driven by our greenhouse gas emissions. Forecasts for 21st-century sea level rise vary between 1 and 2 metres. As the climate warms, so does seawater, and when water warms it expands, causing the sea to rise.

PAUL SOUDERS/GETTY

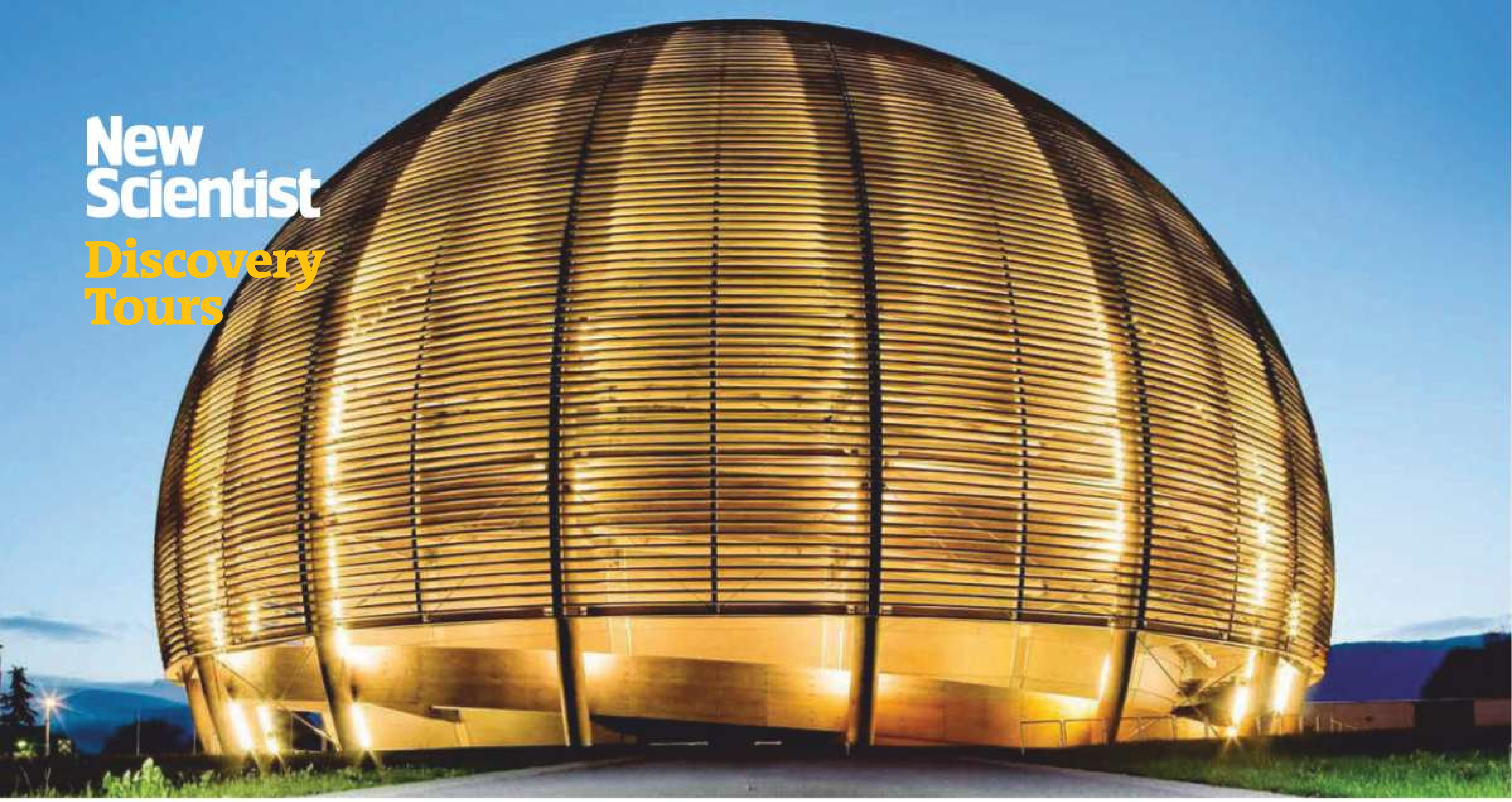
Sea levels are forecast to rise between 1 and 2 metres this century

In the 20th century, this thermal expansion was the main driver of sea level rise, says Jonathan Bamber at the University of Bristol, who collaborated on the work. As a result, the mass of the oceans stayed about the same, even as their volume grew.

Now, a warmer climate is melting the ice in glaciers and the great ice caps, causing more water to flow into the sea. That is steadily increasing the mass of the oceans and pressing the seabed downwards.

Both Vishwakarma and Bamber emphasise that the finding will make no meaningful difference to future sea level rise. While the sinking seabed will slow sea level rise, the effect is too small to be meaningful because the seabed is sinking about 30 times more slowly than sea levels are rising. ▮

Michael Marshall



New Scientist
Discovery Tours

SWITZERLAND / FRANCE

Explore dark & frozen matter: CERN & Mont Blanc

Particle physicist Dr Darren Price and science journalist Laura Spinney will lead a fascinating and insightful tour focusing on CERN, home to the famous Large Hadron Collider, and Mont Blanc to investigate receding glaciers. Fall in love with the charming lakeside city of Geneva, famous for its watch-making, high quality chocolate and enchanting old town.

Tour highlights include:

- **Evening talks and walking seminars with Dr Darren Price and Laura Spinney**
- **CERN guided tour to learn about the groundbreaking work being carried out**
- **Walking tour of Geneva's old town centre and beautiful cruise on Lake Geneva**
- **Cable-car trip to the top of the Auguille du Midi overlooking Mont Blanc**
- **The stunning botanical gardens**
- **Visit the beautiful small town of Chamonix and then on to Mer de Glace to witness an ice cave carved into the glacier itself**
- **Trip to Geneva's Museum of the History of Science, which features astronomy, microscopy and meteorology exhibits**

No single supplements for the first two solo travellers on each departure.
There are only 22 places available per tour, which are expected to fill up very quickly.
Please enquire early to secure your place.

To book call +44 207 593 2284
(UK office: Mon-Fri 9am to 6pm, Sat 9am to 4pm GMT)
Or email culturaltours@kirkerholidays.com

newscientist.com/tours

Departing:
18 May 2020
17 September 2020
6 days for £2,699 (approx $3,429)

In partnership with Kirker Holidays

Kirker
ABTA ABTA No.V6595 AITO Assured

Space

Astronomers want to halt Starlink

Legal action may be pursued to stop thousands of satellites clogging up the sky

Jonathan O'Callaghan

A GROUP of astronomers has called for legal action to stop the launch of vast numbers of satellites designed to beam high-speed internet around the world, until their impact on the night sky can be assessed.

US firm SpaceX has already launched 240 satellites as part of its planned Starlink constellation of up to 42,000 satellites. Others, such as the UK company OneWeb, plan to launch hundreds of their own. There are currently 1500 active satellites orbiting Earth.

Starlink satellites have created bright streaks in some telescope images, affecting astronomical observations. Some worry that the thousands of bright points of light could alter the sky for the public and astronomers forever.

"The ideal thing would be to stop the deployment of these kind of satellites until the problem is very well studied. We have to understand what the impact is on the sky," says Michele Maris at the Astronomical Observatory of Trieste in Italy, part of the group calling for legal action.

SPACEX/FLICKR

SpaceX launched more Starlink satellites on 29 January

To halt mega constellations, the group says that a case could be brought to the International Court of Justice to argue that the night sky is a shared human right under the World Heritage Convention. "The harm here is damage to our cultural heritage, the night sky, and monetary damages due to the loss of radio and other types of astronomy," the scientists write (arxiv.org/abs/2001.10952).

Alternatively, the group says a case could be filed against the Federal Communications Commission (FCC) in the US for licensing Starlink, which the astronomers say may have been in breach of the National Environmental Policy Act (NEPA).

"It would be desirable to adopt contingent and limiting resolutions to be ratified as shared international rules," the astronomers write. They also suggest that, in the meantime, all mega constellations should be put on hold. An associated petition to temporarily halt further launches has more than 1400 signatures.

Chris Johnson, a space law adviser at the Colorado-based pressure group the Secure World Foundation, says that the chances of legal action being successful are slim, but there is an argument that could be made.

"It's time for the larger space community to think what means more: ground-based astronomy and traditional views of the night sky or cheaper internet from space," he says.

The FCC said in a statement it "strongly reject[ed]" any claims it has violated NEPA and its approval of Starlink was "entirely lawful".

SpaceX has attempted to ease concerns by testing a Starlink satellite coated in a darker material so that it won't reflect as much light. However, launches are ongoing, with SpaceX set to send up 1500 Starlink satellites in 2020.

"If it is not possible to leave a better planet for future generations, we can at least try not to make it worse," says group member Stefano Gallozzi at the Astronomical Observatory of Rome in Italy. ▮

Robotics

3D-printed robots can sweat to cool themselves down

ROBOTS are becoming more human-like every day, and now they can sweat.

Thomas Wallin at Cornell University in New York and his colleagues have created soft robotic grippers that are capable of sweating to cool down.

The grippers can achieve a cooling capacity of 107 watts per kilogram, making them more efficient sweaters than mammals. By comparison, humans and horses have a maximum cooling capacity of about 35 watts per kilogram.

Each gripper consists of three finger-like parts that bend simultaneously to grasp small objects. The 3D-printed grippers are made from hydrogels, polymer materials that can store large amounts of water. Each finger has an underlayer with an internal channel to let fluid flow and is capped with a surface layer containing micropores.

At cold temperatures, the pores close. At temperatures higher than 30°C, the surface layer expands, dilating the pores and enabling pressurised fluid from the underlayer to sweat out. The material responds spontaneously to temperature changes without the need for external sensors (*Science Robotics*, doi.org/dkvd).

"Sweating takes advantage of evaporative water loss to rapidly dissipate heat," says Wallin. Unlike convection or radiation, sweating lowers the temperature of a body below that of its environment. "When the local temperature rose above the transition [temperature], the pores would simply open and close on their own," he says. When blown by wind from a fan, the sweating robots cooled at a rate of 39.1°C per minute, about six times as fast as similar devices that are unable to sweat.

"When the local temperature rose, the pores would simply open and close on their own"

However, there is currently no means to replenish the robot's fluid stores after sweating. This means "the robots would have to also be able to drink", says team member Robert Shepherd, also at Cornell. ▮

Donna Lu

Climate change

World's hottest year yet likely to happen before 2025

Adam Vaughan

A NEW world record for the hottest year may be set before 2025, according to the UK Met Office. There is even an outside chance that temperatures will temporarily overshoot the toughest target of the Paris climate deal.

The past decade was the warmest on record, with the title of warmest year held by 2016 – when climate change and the El Niño phenomenon drove temperatures 1.16°C above pre-industrial levels.

In a forecast that was based on 20 computer models, the Met Office says there is a more than 66 per cent chance that the 2016 record will be beaten between 2020 and 2024.

"It's really a sign the planet is warming. To get another [record] in the next five years is consistent with the warming trend," says Doug Smith at the Met Office.

The forecast shows that any one year between 2020 and 2024 is likely to be between 1.06°C and 1.62°C warmer, meaning it could be more than 1.5°C above pre-industrial levels, the target that world leaders have pledged to "pursue efforts" to avoid.

But one year above the threshold would be symbolic rather than a sign that the Paris target has been irrevocably breached. For the Paris goals, what matters is the consistent annual norm across several years.

The chance of any year before 2025 being more than 1.5°C warmer is also low, less than 10 per cent, in the Met Office analysis. Still, if the milestone did come to pass, says Smith, "it would be the first indication that we are starting to get close [to the Paris limit]".

The global average masks the fact that some regions are already seeing much hotter temperatures. In 2019, Australia had its hottest year ever, at 1.52°C above average, and Europe had its warmest year too, at 3.2°C above average. ▮

Analysis **E-cigarettes**

The teenage epidemic that wasn't

Vaping is supposedly sweeping US schools, but it is actually fairly rare among teenagers who have never smoked, says **Clare Wilson**

"How Juul hooked a generation on nicotine" was a *New York Times* headline from 2018 on the new addiction apparently sweeping the youth of the US. It wasn't the only media outlet to cover the rise in e-cigarette use, after a US government survey from that year showed that vaping among teenagers was on the rise.

The full figures from this survey have now been newly analysed and they suggest that the original coverage didn't give the whole picture. In some ways, the results could even be seen as good news for teenagers' health.

E-cigarettes are meant to be a safer way for people to inhale nicotine without taking in the multiple harmful substances produced by smoking tobacco, like tar and carbon monoxide.

There have always been worries that, as well as helping smokers quit, they might lure in non-smokers. In the past few years, concerns have spiralled in the US over small vaping devices branded Juul that deliver a big hit of nicotine with a wide choice of flavours.

Have vaping rates in young people been overblown?

ARTRANO/GETTY

Juul's purported appeal to teens was highlighted by the US Centers for Disease Control and Prevention when it released the 2018 figures. The study was based on its annual survey of more than 20,000 middle and high-school students and triggered a rash of alarming headlines.

> "There has been a focus on teens without making it clear that many would be smoking anyway"

At the time, Juul said it didn't want young people using its products and stopped selling some of its flavours through retail stores. It has since withdrawn all non-tobacco or menthol flavours from the market.

An independent analysis of the full set of those figures, published this week, is more nuanced than those initial headlines (*Nicotine & Tobacco Research*, doi.org/ggjd39). While 14 per cent of the teens surveyed had indeed vaped in the past 30 days, only 4 per cent of the total were regular e-cigarette users, defined as having done so on 20 days or more over that period. Less frequent use suggests "curiosity and experimentation", says author David Abrams at the New York University School of Global Public Health.

And the figures suggest that, far from hooking a new generation on nicotine, comparatively few teens who have never smoked take up vaping: less than 1 per cent of those who were vaping regularly had never smoked tobacco before. "There has been a massive focus on teens without making it clear that most of these teens would be smoking anyway," says Abrams.

But the idea of a new addiction epidemic among the nation's youth has now taken hold. The US has recently banned all flavours of vapes apart from tobacco and menthol. Yet this could be counterproductive in terms of protecting people's health. Research suggests that many adults are also keen on sweet-flavoured vapes, including fruit, sweets and desserts, and it can be part of the appeal of switching from smoking to vaping.

Complicating matters is that fears over e-cigarettes have risen after reports last year of a strange lung illness linked with vaping, which has so far caused more than 50 deaths. Further investigation has revealed that these cases actually involved people using black market cannabis vaping liquid that has been bulked up with a harmful additive, vitamin E acetate.

Many media reports have implied that the danger comes from all e-cigarettes, even legal ones that deliver nicotine, which just isn't true. Yes, we need to make sure that teenagers don't take up vaping or smoking, but that shouldn't come at the cost of scaring existing adult smokers from switching to vapes. ▮

Machine learning

AI attempts to pick embryos with the best chance of IVF success

Donna Lu

ARTIFICIAL intelligence is helping to select embryos for IVF that have a higher chance of resulting in a successful pregnancy.

The AI algorithm, called Ivy, analyses time-lapse videos of embryos as they are incubated after being fertilised, and identifies which ones have the highest likelihood of success.

It was developed by Harrison.ai, a tech firm in Sydney, and has been used for several thousand women undergoing IVF in Australia. People who undergo IVF using Ivy are informed about the algorithm and consent to its use.

Ivy was trained on more than 10,000 videos of embryos growing inside an incubator for five days, in combination with data about which embryos resulted in pregnancy. The model is more accurate than trained specialists at predicting the likelihood that an embryo will go on to develop a fetal heartbeat at or beyond seven weeks of gestation.

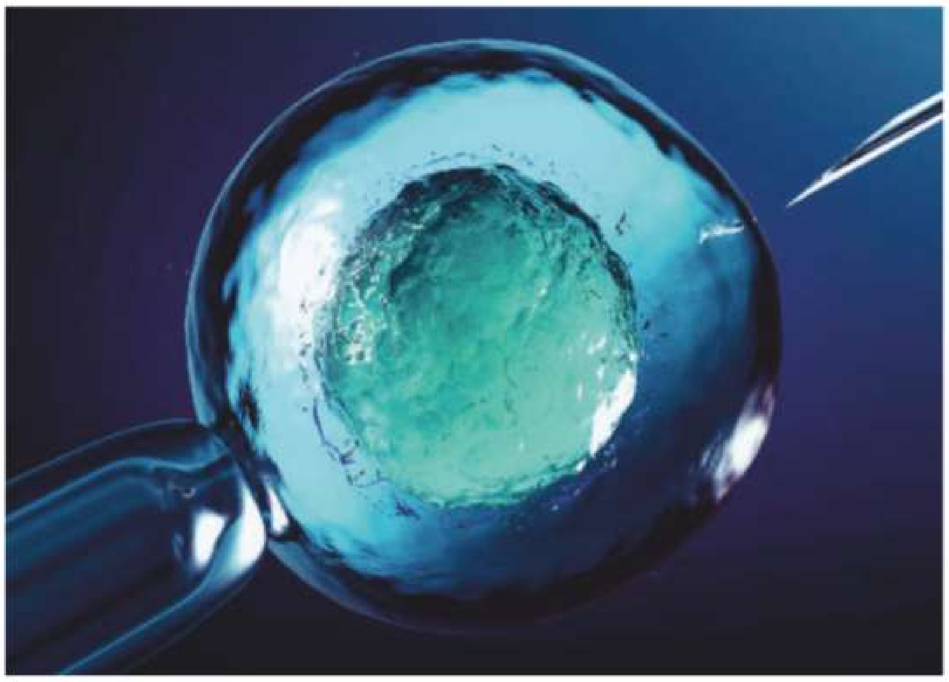
In a study of its predictive ability, Ivy scored 0.93 on a measure known as AUC, where a score of 1 indicates a model with predictions that are 100 per cent correct. Trained human embryologists have previously scored an AUC of around 0.74.

"The results look very promising," says Iman Hajirasouliha at Cornell University in New York. He and his colleagues have developed a similar AI, Stork.

What these AIs are identifying in the videos as a marker of success isn't entirely clear. "It's still a bit of a black box," says Aengus Tran, CEO of Harrison.ai.

"We could speculate that it must have learned very similar features to what embryologists are looking at," says Tran. These might include the shape of cells or how long it takes to go from two to eight cells.

Ivy may also have picked up on features that human specialists don't look at, says Tran. While embryologists look only at video snippets of key events of an embryo's development, Ivy is able to rapidly analyse the entirety of five days of footage.



CHRISTOPH BURGSTEDT/SCIENCE PHOTO LIBRARY

Eggs undergoing IVF have different probabilities of developing into embryos

Ivy is now routinely used as a tool in embryo selection by IVF Australia, which provides about 20 per cent of the country's IVF services. "Because we think it's a better predictor than the embryologists, we are choosing the embryos with Ivy most of the time," says Peter Illingworth at IVF Australia.

A clinical trial will begin next month to determine whether people undergoing IVF whose embryos are selected by Ivy become pregnant more quickly than those whose embryos are selected by human specialists.

In an average IVF cycle, a parent starts with 10 eggs that result in three potentially viable fertilised embryos after five days, says Illingworth. One is implanted, and the rest are frozen and stored.

"Ultimately, what you really want is one IVF cycle resulting in one embryo being transferred and one healthy baby," says Tran.

"What we're not doing is using Ivy to decide which embryos we will freeze and keep," says Illingworth. "Ivy will never make the difference between a woman having a baby or not having a baby." ▮

Quantum physics

Nanoparticle quantum chilled to near absolute zero

A NEW method for manipulating the quantum state of particles has been used to chill a tiny glass bead into its coldest possible quantum state.

Once you get down to extremely small scales, heat and motion are interchangeable: the more a particle is moving, the hotter it is. So to cool down a small particle, you have to stop it moving. Because the rules of quantum mechanics mean you can never know exactly how fast a particle is moving, there is a limit to how cold a particle can get. When a particle is at that limit, we say it has reached its ground state.

Markus Aspelmeyer at the University of Vienna in Austria and his colleagues used a single laser to cool a 150-nanometre-wide glass particle into its ground state (*Science*, doi.org/dkvw).

The laser levitated the particle through an effect called optical trapping, in which the light interacted with the particle to hold it in place. Mirrors either side of the particle caused the light to overlap and interfere with itself.

This interfering light could only exist in certain frequencies, according to quantum mechanics. That allowed the researchers to select the precise frequencies of light that hit the particle. As the particle vibrated back and forth, some frequencies of light would have sped it up by imparting small amounts of energy, while others would have slowed it down by removing energy.

Allowing only the frequencies that slowed the particle meant it kept cooling until it reached its ground state. This occurred at a temperature of 0.000012 kelvin (about -273°C), just a fraction above absolute zero, the minimum temperature possible. ▮

-273°C

Temperature the nanoparticle was cooled to

Leah Crane

Darwin's Galapagos with Jo Ruxton

Explore the Galapagos Islands from the comfort of a luxury small-berth yacht accompanied by marine conservationist and documentary producer Jo Ruxton

A paradise for natural history, animal and geology lovers, we have curated a distinctive trip which includes the UNESCO World Cultural Heritage Site of Quito followed by eight days exploring at sea and exclusive behind the scenes access at the Galapagos Science Centre. The spacious and stylish yacht Natural Paradise is small enough to get into bays that larger expedition ships cannot go near, so you get to experience Galapagos as Darwin did.

Galapagos sea lions, marine iguanas lounging on the shores, blue-footed boobies patrolling the skies, giant tortoises, sally lightfoot crabs and green sea turtles are just a few of the animals native to this fascinating archipelago.

Highlights of the tour include:

- **Explore eight varied islands including Isabela, Espanola and Fernandina**
- **Exclusive behind the scenes access at the Galapagos Science Centre**
- **Jo Ruxton will give talks on board covering marine conservation as well as accompanying the daily excursions**
- **Local naturalist guides will accompany the voyage and give seminars at sea and on land**
- **Lots of opportunities to visit the many islands by panga boat and snorkel in these amazing waters**
- **Observe a wide variety of wildlife including reef sharks, nazca, blue-footed boobies, sea lions, Galapagos penguins, seahorses, sea turtles and the strange yet fascinating mola.**
- **Explore Latin America's largest and best-preserved historic centre and colonial quarters in Ecuador's capital, Quito**

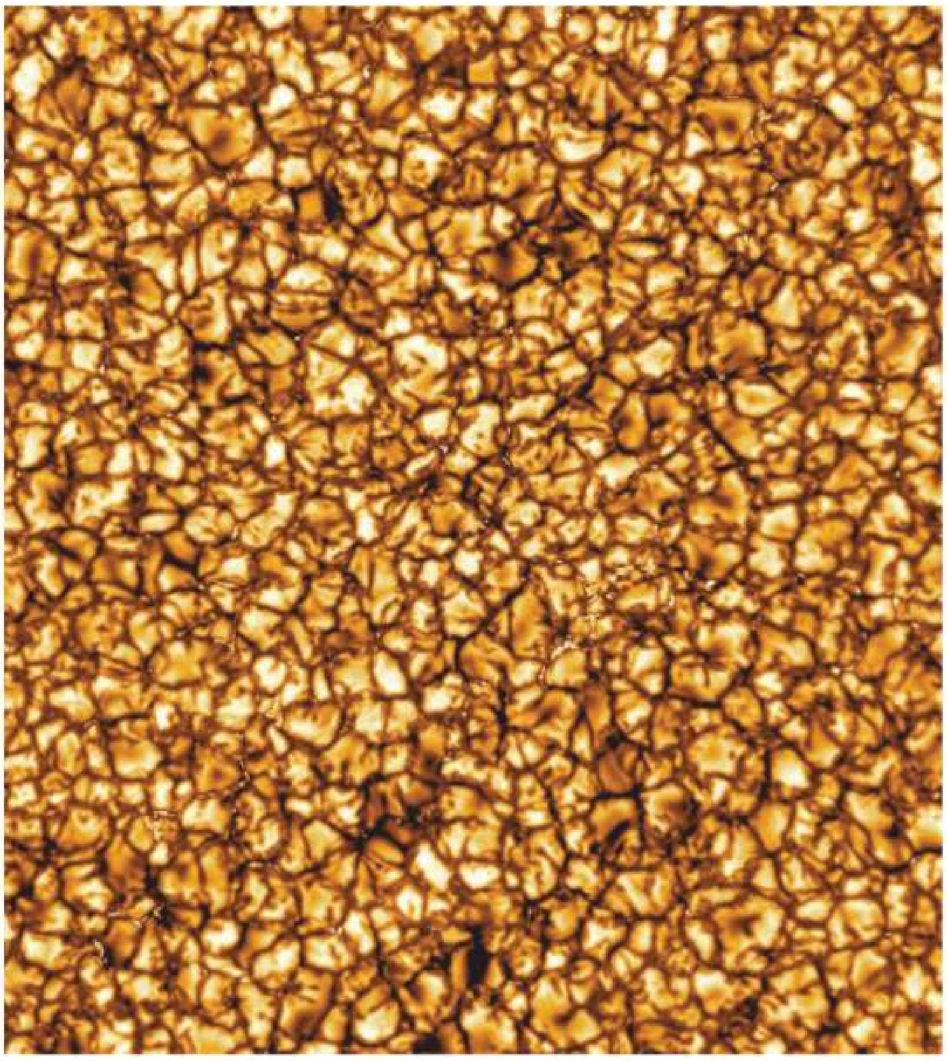
newscientist.com/tours

Departing:
7 June 2020
11 days for £6,995 (approx $8,885)

To book call
+44 1285 601 571
(UK hours Mon to Thu 9-5:30 Fri 9-5 GMT)
Or email
newscientist@steppestravel.com

In partnership with Steppes Travel

Steppes Travel



NSO/AURA/NSF

Space

Sun's surface revealed in all its glorious detail

THIS is the best picture we have ever taken of the surface of the sun. It was captured by the Daniel K. Inouye Solar Telescope (DKIST) in Hawaii, the largest of its kind, on its first day observing our star.

The honeycomb-like pattern is made up of "cells" of plasma that roil over the sun's surface and draw heat out from the centre. The bright centres of the cells mark where plasma is rising, and the dark outlines where it is sinking. Each cell is hundreds of kilometres across.

This image has more than five times the resolution of pictures from the next-best solar telescope, said Thomas Rimmele, the director of DKIST, during a press call. It shows structures that are as small as 30 kilometres across. "We have now seen the smallest details on the largest object in our solar system," said Rimmele. "What we previously thought looked like a bright point, one structure, is now breaking down into many smaller structures."

This is just the beginning. The image was taken on 10 December, the first day of the telescope's operations. In the next six months, after new instruments are installed, DKIST will be able to measure the magnetic fields of these relatively small features on the sun in addition to taking pictures of them. Rimmele hopes that such measurements will help us figure out why the tenuous outer layer of the sun, the corona, is so much hotter than the surface.

DKIST is also intended to help us predict solar eruptions. These are when the sun sends blasts of plasma towards Earth that can pose a danger to our satellites and electric grids. **Leah Crane**

Genetics

Modified moths head into the field

MALE diamondback moths genetically modified to wipe out pest populations of their own species have been released in New York state as part of a field trial. The female offspring of these GM moths die soon after hatching.

Oxitec, the UK biotechnology company behind the trial, has already staged field trials of this method for mosquitoes. However, the moth field test is the first for a crop pest, the company says.

The larvae of the diamondback moth (*Plutella xylostella*) eat the leaves of brassica plants such as cabbage, kale and oilseed rape (canola), causing global damage estimated at $5 billion a year.

The GM moths were given a gene that kills larvae soon after they hatch – but it switches on only in females. When male GM moths mate with wild females, all the female offspring die, but the males survive and pass the lethal gene on to their offspring. Because half the offspring of the GM males die each generation, the gene should disappear after just a few generations. To continue to curb wild populations, more GM males would need to be released.

In field trials in August and September 2017, between 1000 and 2500 males were released on six separate occasions. The team then recaptured some of the moths to confirm that they survived in the wild. It says the moths should be as competitive with wild male moths in mating with females as they were in lab trials. As expected, the GM strain didn't persist in the wild (*Frontiers in Bioengineering and Biotechnology*, doi.org/dkvp).

Oxitec hopes to get approval to start selling its GM diamondback moths to farmers in the US. It also plans to use the same technology to tackle other crop pests, such as the highly destructive fall armyworm. **Michael Le Page**

Health

A tablet that could replace injections

A PILL that could replace conventional injections has passed its first tests in people with flying colours, according to the company developing it.

"It's completely pain-free," says Mir Imran at Rani Therapeutics of San Jose, California.

He says the results provide hope for millions of people – such as those with diabetes – who want an alternative to painful injections.

RANI THERAPEUTICS

The RaniPill looks like a larger version of a normal pill. When swallowed, it passes through the stomach, only breaking open in the intestine. A small balloon then inflates and pushes a small, dissolvable needle into the wall of the intestine, injecting a drug. The pill's contents are then excreted. The intestine has no receptors for sharp pain and heals quickly.

In a trial in Australia, 52 people were given RaniPills containing octreotide, a drug used to treat certain cancers and growth disorders. They felt no pain or discomfort, and the pill was as effective at delivering the drug as conventional injections.

One hope is to use it to create an insulin pill for people with diabetes. The stomach degrades insulin, so at the moment it must be injected conventionally. But people who hate needles often delay or skip injections. "The development of oral insulin would be a breakthrough," says Edward Johnston at Diabetes UK. **MLP**

New Scientist Daily
Get the latest scientific discoveries in your inbox
newscientist.com/sign-up

Really brief

FRANK BIENEWALD/ALAMY

Microbiome change counters bee virus

Honeybee gut bacteria have been genetically modified to protect the insects against a lethal infection that can cause colonies to collapse. Researchers at the University of Texas, Austin, engineered a bee gut bacterium to generate RNA that disables the deformed wing virus (*Science*, doi.org/dkvq).

Cyborg jellyfish swim a lot faster

Electronics embedded in live jellyfish allow them to be remote-controlled by stimulating muscle contractions so they swim at three times their normal pace. The hope is to use the animals to monitor oceans by adding sensors to check oxygen content and temperature (*Science Advances*, doi.org/dkvt).

Fatal accidents rise after clock change

The risk of fatal car crashes goes up about 6 per cent in the week after summer time starts before returning to normal. Researchers say about 29 deadly accidents in the US in the week after the transition could be avoided each year if clocks weren't changed (*Current Biology*, doi.org/dkt5).

Ancient humans

Lots of us are a bit more Neanderthal

PEOPLE of European and African ancestry have more Neanderthal DNA in their genomes than previously thought. This is the finding of a study that identifies, for the first time, the Neanderthal genes present in modern day people of African ancestry.

Neanderthals lived in Europe and central Asia until their demise some 40,000 years ago. Thanks to genetic studies, we know that after modern humans left Africa, they interbred with Neanderthals, leaving traces in each other's DNA.

Previous research showed that about 1.5 per cent of the DNA of people of European ancestry came from these events, while people of east Asian ancestry had a bit more than this. Because genomes of people of African ancestry showed little or no evidence of this genetic exchange, Neanderthal genes were identified in people of European ancestry by comparing their genomes with people of African ancestry, assuming they were a Neanderthal-free baseline.

To find out if this assumption was correct, Joshua Akey at Princeton University and his team devised a new method of detecting archaic ancestry in DNA. Looking at genomes of people of African ancestry in Africa and elsewhere in the world today, this revealed an unexpectedly high Neanderthal signature of 0.3 per cent in people of African ancestry, compared with less than 0.02 per cent in earlier studies (*Cell*, doi.org/dkvs).

By extension, that result means the Neanderthal component of the genomes of modern-day people of European ancestry was underestimated. **Alison George**

Diet

10'000 HOURS/GETTY

Vegetarians may have a lower risk of getting UTIs

A VEGETARIAN diet has been linked with a lower risk of having a urinary tract infection, at least for women.

The infections are usually caused by bacteria from faeces entering the urinary tract. Chicken and pork are a major reservoir of *E. coli*, a bacteria that commonly causes UTIs. So Chin-Lon Lin at Tzu Chi University in Taiwan and his colleagues looked at whether vegetarians would have a lower risk of UTIs than meat-eaters.

They looked at 9724 people in Taiwan over 10 years and found that vegetarians were 16 per cent less likely to have a UTI than their meat-eating counterparts. But when the researchers analysed the diets of men and women separately, they found the protective effect was present in women but not men (*Scientific Reports*, doi.org/dkvm).

Lin says vegetarians may have a lower risk of UTIs because they have a lower risk of exposure to *E. coli*. It is also possible that the high fibre content in their diet helps them to avoid constipation and reduces the risk of *E. coli* growing in their gut.

However, there are caveats. For example, the participants were all Buddhists based in Taiwan. And while the study tried to adjust for some factors, it didn't account for pregnancy, which is a major risk factor for UTIs. **Adam Vaughan**

Astronomy

Two stars have a strange jiggly orbit

A PAIR of distant stars are locked in a weird, wobbly dance, probably the result of an effect predicted by the theory of general relativity.

One of the stars, PSR J1141-6545, is a pulsar, a dense neutron star that emits beams of light. It orbits a white dwarf, which formed when a lower-mass star ran out of fuel and lost its outer layers.

Using years of observations, Vivek Venkatraman Krishnan at the Max Planck Institute for Radio Astronomy in Germany and his team calculated the stars' orbits around one another with extreme precision and found it was wobbly.

This oddity is due to an effect called frame dragging, which is predicted in the theory of general relativity and occurs when a fast-spinning object drags space-time around it. The researchers worked out that the white dwarf is spinning faster than the pulsar, which is twirling fairly slowly at about 2.5 rotations per second.

That indicates the system seems to have formed in an unexpected order. Usually, the pulsar forms first, and then as the white dwarf is losing its outer layers, the pulsar sucks up that material and starts to spin faster. In this case the white dwarf formed first (*Science*, doi.org/dkvx). **LC**

Climate change

Nuclear winter

The rise of renewable energy means nuclear power is on the decline. Is it about to go extinct, asks **Adam Vaughan**

NUCLEAR power is meant to play a key role in holding global warming below a rise of 1.5°C, but the world's nuclear plants are quietly starting to show their age – and some people are wondering if we should give up on them altogether.

The UK has eight nuclear plants, a cornerstone of the country's energy system, but two – Hunterston B on the west coast of Scotland and Dungeness B in south-east England – have been silent since 2018.

Hunterston, which started generating electricity in 1976, has been offline because of concerns over cracks in the graphite bricks that control the nuclear reaction, although one reactor could come back online late this month. Dungeness, generating since 1983, has been down for repairs to pipes carrying steam, and isn't due back until April at best.

"Nuclear is effectively infinite, scalable. It is the only thing that's going to work for climate change"

This picture isn't confined to the UK. There are 415 reactors operating around the world, supplying 10 per cent of the world's electricity supply, but that is down from a high of around 17.5 per cent in 1996, according to a report published last month (see graphs, right).

For the first time, the average reactor age passed the 30-year mark. Five reactors shut down last year, while construction started on just two new reactors. The number being built globally stood at 46 by mid-2019, a decadal low, with 10 of them in China.

"To me it's very clear now that the renewal rate of nuclear power is too small to be sustainable. So this species will die out," says Mycle Schneider, a Paris-based nuclear consultant and a lead author of the report, the World Nuclear Industry Status Report 2019.

That has big ramifications for climate change. The UK's growth in low-carbon electricity production stalled in 2019, after a decade of progress, thanks to the nuclear plant issues, a recent analysis by Carbon Brief found.

The hiatus is likely to be a foretaste of the next few years. Seven of the UK's plants will have been retired by 2030, stalling the carbon savings from a rapid growth in renewables. Theoretically, a big new nuclear plant – Hinkley Point C – will come online in 2025, but EDF, the company behind it, has already warned of delays.

So should the world double down on nuclear power and do whatever it takes to get more plants built? Or is time to abandon the idea of nuclear as an important tool for fighting climate change?

CHRISTOPHER JONES/ALAMY STOCK PHOTO

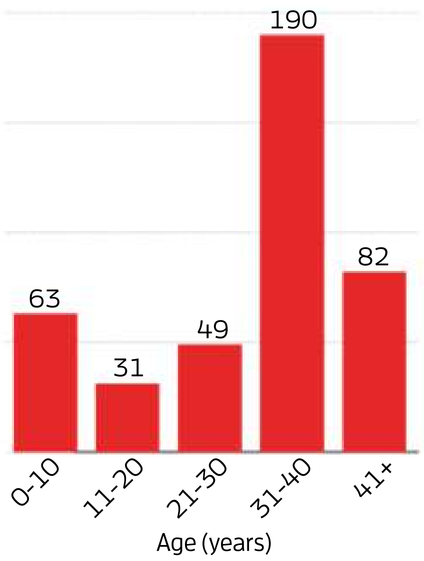
"I would frame the question differently," says Michael Shellenberger at Environmental Progress, a US-based non-profit organisation. "Can renewables be part of the climate fight? Look, there's just these inherent physical limits to renewables because of the dilute nature of sunlight and wind, and their inherent unreliability, whereas nuclear is effectively infinite, scalable. Nuclear is really the only thing that's going to work for climate."

In a letter sent to US president Donald Trump last month, Shellenberger and other nuclear advocates complained that the US is building only one nuclear plant at home and none abroad, and that two-thirds of current US plants may retire within two decades. "The US nuclear industry needs your leadership to grow nuclear at home and sell American nuclear plants abroad," they said.

Matt Bowen at Columbia University in New York says that while Trump backs nuclear power, he has done little to help it. The president's decision to pull the US out of the Paris climate agreement means the country has no policies that would improve the economics of nuclear, such as putting a price on carbon. "I want to believe the US will have some sort of climate policy. I think that's key to nuclear energy's future," says Bowen.

Ageing energy

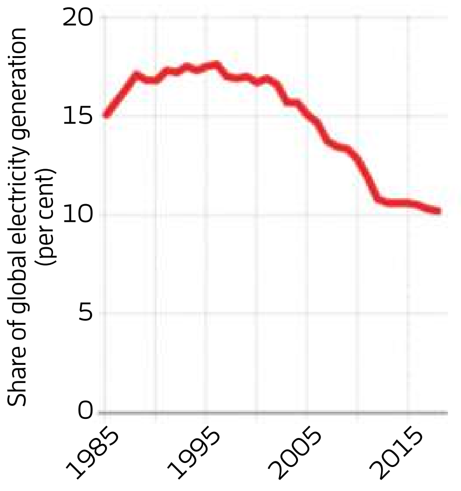
Almost two-thirds of operating nuclear reactors are now over 30 years old



SOURCE: WORLD NUCLEAR INDUSTRY STATUS REPORT 2019

Shrinking share

Nuclear's share of world electricity generation is shrinking despite overall nuclear output climbing back towards levels seen before the Fukushima disaster



SOURCE: WORLD NUCLEAR INDUSTRY STATUS REPORT 2019

Overwhelmed by climate change?
Get Adam Vaughan's weekly newsletter on how to fix the planet
newscientist.com/sign-up/fix-the-planet

The UK's nuclear facilities are starting to show their age

Competition from the falling cost of renewables is another reason that new nuclear plants face an uphill challenge in some countries. The cost per megawatt hour of subsidising offshore wind farms in the UK is now half of that agreed for Hinkley Point C, meaning even accounting for the costs to the grid of their variable nature, they are still much cheaper than nuclear.

Antony Froggatt at UK think tank Chatham House says there used to be a clear contrast on cost between nuclear and renewables. "But now I think what we are seeing is the cost of renewables is going below that of all [forms of electricity] generation."

Europe has meanwhile seen a political backlash against nuclear power following the disaster that struck the Fukushima plant in Japan in 2011. Germany opted to close its own plants, and the last will be retired in 2022. As a result, Germany's emissions grew by about 100 million tonnes of carbon dioxide a year, roughly a quarter of the UK's annual emissions, according to Carbon Brief's estimates. One recent analysis put the increased healthcare and social cost at $12 billion a year because of the air pollution from coal plants filling the gap left by nuclear.

Switzerland has also voted to phase nuclear out and Belgium will shut its reactors by 2025. Even atomic stronghold France is planning to drop nuclear from 75 per cent of the country's electricity to 50 per cent through installing more wind and solar power.

Such phase-outs mostly work by letting plants come to the natural end of their life. But Amory Lovins at the Rocky Mountain Institute in Colorado takes a more extreme view that existing nuclear plants are now so expensive to run that they should be shut down early.

"Today's hot question is whether existing reactors should keep operating," he says. "Most of them cost more to run than their output can earn, and more than it would cost to provide the same services by building and operating new renewables or by using electricity more efficiently."

Shellenberger disagrees with how Lovins counts the costs of nuclear, and many observers think nuclear plants should have their lives extended rather than being retired. Catherine Mitchell at the University of Exeter, UK, a critic of nuclear power, says she doesn't mind extensions so long as they are safe, don't last too long and are overseen by a good regulator.

This is the approach being taken in Florida, where the US regulator recently approved reactors to operate for 80 years, up from 60 years. "It's the way to go," says Bowen. The UK's regulator could in theory make a similar decision, but whether it would be economical for EDF, which owns all of the UK's nuclear plants, to do so is another matter, given the ageing problems at Hunterston and Dungeness.

Is the sun about to set on the nuclear power industry?

TONY VINGERHOETS/ALAMY STOCK PHOTO

Some are looking to other forms of nuclear power instead. Mini plants known as small modular reactors, such as those being developed by US firm NuScale, are one possibility, but Shellenberger says going smaller won't make nuclear more economical in the face of the rise of renewables.

415

The number of nuclear reactors operating around the world

Then there is nuclear fusion, a cleaner source of energy than current nuclear fission plants. Unfortunately, it is still too far off to help us prevent the globe warming by more than 1.5°C, which requires halving global emissions by 2030.

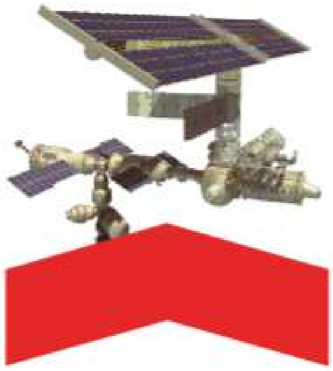
A UK government-backed fusion project is trying to build a commercial fusion power station by 2040, and two UK private firms think they could deliver a working reactor by 2030. None are guaranteed to succeed, though.

In the meantime, the nuclear industry will keep making its case for being crucial to tackling climate change by reducing emissions to net zero. "Net zero needs nuclear NOW," the UK nuclear trade body tweeted recently.

Shellenberger says he is bullish about nuclear's long-term prospects, and China's efforts both domestically and abroad will be key. But nuclear power's prospects in the short term are chaotic and unpredictable, he says. "In the short-term, it's a knife fight in a phone booth. It's everywhere, it's difficult, it's complicated." ■

Working hypothesis

Sorting the week's supernovae from the absolute zeros



▲ Space hotel

NASA is working with Axiom Space to build a tourist module for the International Space Station. Could you handle the #flightshame?

▲ New aurora

Paging Philip Pullman. A new kind of northern light has been spotted: green waves of light known as auroral dunes.

▼ Overweight owl

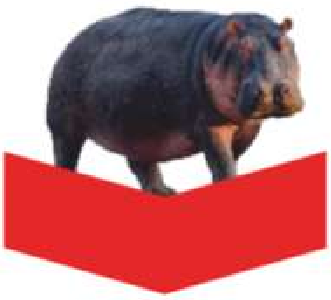
An owl rescued from a ditch has been put on a diet by the Suffolk Owl Sanctuary, UK. It was too fat to fly home.

▼ Cigarette butts

Even stubbing out isn't enough. A study has found that in one day, a used butt can emit up to 14 per cent of the nicotine released by an actively burning cigarette.

▼ Drug lord hippos

A group of four hippos that were once owned by Colombian drug lord Pablo Escobar has ballooned to 80 animals, and they are altering local ecosystems.



NASA; IMAGEBROKER/ALAMY

SUBSCRIPTION OFFER

NewScientist

Subscribe today
from only $1.91 a week*

As a *New Scientist* subscriber you also benefit exclusively from:

- Free weekly print delivery to your door
- The *New Scientist* app, giving you instant access anytime, anywhere, including
  - Current and back issues of *New Scientist*
  - All issues of ***New Scientist: The Collection*** - worth $9.99 each!
- Full access to newscientist.com with
  - Over 30 years of archive content
  - 100+ science talk videos
  - Early access to magazine features online

For easy online sign-up, visit newscientist.com/13565
Or call 1 888 822 3242, quoting reference 13565

* A digital subscription package to New Scientist costs $1.93 a week, made payable by quarterly continuous payment methods

Views

The columnist
Graham Lawton on why aiming for net zero could work **p24**

Letters
Ask an AI to explain how an AI made a decision **p26**

Aperture
A swarm of locusts flies through Kenya eating crops **p28**

Culture
How to fight back against everyday racism **p30**

Culture columnist
Sally Adee on sci-fi that turns our cities "smart" **p32**

Comment

The evolution of sexuality

Same-sex attraction isn't an evolutionary paradox – our explanations for how it came to be are just wrong, says **Andrew Barron**

HOW did human same-sex attraction come to be? At first glance it seems to be an evolutionary paradox. For a trait to evolve, it has to be passed on to children to whom it confers some sort of advantage. But as gay sex, of itself, cannot yield offspring, we should expect same-sex attraction to go extinct.

Evolutionary biologists have long struggled with this paradox, but my colleagues and I believe that if you come to the puzzle from a different angle, the apparent contradiction disappears. The trick is to recognise the complexity of human sexual activity and sexuality.

Firstly, same-sex attraction only looks like a paradox if we consider human populations to be made up of two distinct groups: people who are exclusively gay and people who are exclusively straight. But human sexuality isn't like this.

Every study since the pioneering work of Alfred Kinsey and his colleagues in the 1940s and 50s has backed up the idea that sexuality varies continuously from a majority of people who identify as exclusively straight to a minority of people who identify as exclusively gay. In the middle are a range of people, including those who identify as bisexual, mostly straight or mostly gay.

Acknowledging this spectrum radically changes the evolutionary question. It means that we should be asking how variation in sexuality evolved, not just how same-sex attraction has evolved.

JOSIE FORD

Secondly, the majority of sex, be it gay or straight, isn't for reproduction. For humans and our chimpanzee and bonobo relatives, sex has a range of social functions that include play, social bonding, affiliation and even barter, conflict resolution, dominance and appeasement. Thinking about the evolution of sex has to consider these social functions as well.

My colleague Brian Hare at Duke University and I proposed a new hypothesis for the evolution of same-sex attraction in a recent paper published in *Frontiers in Psychology* (doi.org/dk2x).

An important aspect of recent human evolution has been selection to be proactively social: prosociality. If survival and reproduction depend on being part of a functional social group (as was the case for early humans and our primate ancestors), individuals that are highly prosocial can rapidly integrate into a group, operate better within a group and have greater mobility between groups. Selection for prosociality has resulted in a whole range of traits for greater social awareness and tolerance, better social communication and reduced aggression. This includes an expanded role for sex in social contexts that include adult social bonding, adult play and conflict resolution. That applies to both gay and straight sex.

Consider bonobos, our closest primate relative. They diverged from chimpanzees about 2 million years ago and as a species are extremely prosocial. They are also, famously, highly sexual, using sex (gay and straight) for a range of social functions. We think something similar occurred in recent human evolution. Selection for increased prosociality increased the frequency and diversity of expression of social sex and increased same-sex attractions.

A recent study showed human sexuality could be influenced by hundreds of genes and there is no single gene for same-sex attraction. Instead, many genes influence variation in sexuality, each acting in small and different ways, which may explain the variation we see in people's sexuality.

Variation is expected for complex traits involving hundreds of genes: consider human IQ or height, for example. But we don't feel a need for special evolutionary arguments to explain the existence of very smart or very tall people, they are just one end of spectra of variation. ▮

Andrew Barron is a neuroethologist at Macquarie University in Sydney, Australia

No planet B

Time for action Net zero is the new buzzword in climate circles. Though it has its problems, this goal could finally start to galvanise countries into serious carbon cutting, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

Graham's week

What I'm reading

The Overstory *by Richard Powers, an epic novel involving a lot of trees.*

What I'm watching

It's classic horror season in my house. My son is writing a dissertation on scary films.

What I'm working on

I'm back on the biodiversity beat as we gear up for a big meeting on the issue this month.

This column will appear monthly. Up next week: Annalee Newitz

HERE'S a trivia question for you. What do Bhutan and Suriname have in common? If you said that they are the only countries that, in effect, add no greenhouse gases to the air, a state of grace known as net zero, then well done – though you might want to get out more.

Even if you aren't a climate obsessive, net zero is a phrase you have probably heard. Greta Thunberg talked about it last month at the World Economic Forum meeting in Davos, Switzerland. Last year, the UK and France became the first major economies to legally commit to achieving it; both chose 2050 as year zero. Sweden and New Zealand have also enacted similar net zero targets. Eleven other countries have legislation in the pipeline, with Finland aiming for 2035 and Norway and Uruguay an even more ambitious 2030.

Smaller political entities such as states and cities are increasingly declaring net zero targets, as are big companies. Net zero doesn't change what we have to do, but seems to be focusing minds in a way that vague global temperature goals have failed to do.

On the surface, net zero seems a good idea and a straightforward one. Wherever possible, stop emitting greenhouse gases, and have enough carbon dioxide-absorbing trees to counter any remaining emissions, or capture those emissions and bury them.

Unlike temperature goals, net zero sounds unequivocal. It draws on very solid science – the concept of a carbon budget: the amount of extra CO_2 (or other greenhouse gases) we can emit without cooking Earth. It is clearly a useful way of framing the challenge and aiming for solutions.

Simple. But, as with all things climate-related, there is devil in the detail – and a good deal of wiggle room.

Net zero has loopholes galore, especially aviation and shipping. To achieve national net zero, a country must include all emissions from planes and ships within its airspace and territorial waters. But what about emissions once the craft have flown and sailed into international ones? Historically, these emissions have been exempt from climate change talks because of the difficulty of allocating them to specific countries. But without a mechanism to do so, net zero will be an illusion.

> "Action by the big emitters seems to be moving things on: 18 nations are on a downward net emissions trajectory"

To its credit, the UK government has committed to accounting for these emissions, though has yet to specify how. But other countries may not be so strict.

There's more. Countries could claim to be net zero, but consume products made abroad whose manufacture creates emissions. A requirement to gauge a nation's consumption globally will close this loophole, but in the meantime nations can shift some emissions off their books this way.

Even with a meaningful target, you then have the problem of actually hitting net zero, which is where the hard yards really start. Bhutan and Suriname succeeded largely because they have small populations, lots of hydroelectric power and intact forests. The rest of the world isn't so blessed.

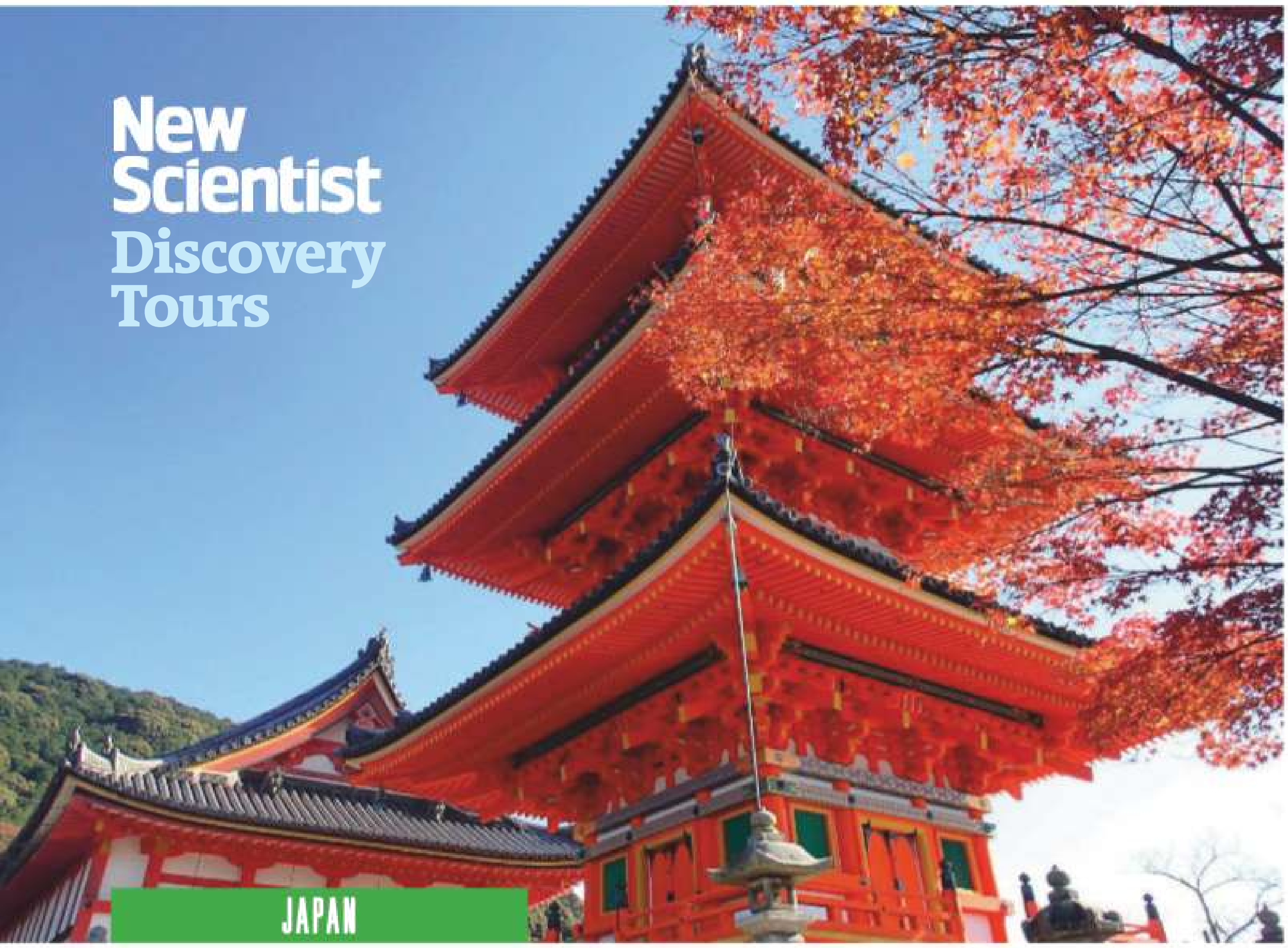
But there is positive evidence that concerted action by the big emitters is moving things in the right direction. Eighteen advanced economies (including the UK) are currently on a downward net emissions trajectory, largely as a result of their climate and energy policies.

At the moment, even the best of them are only achieving an annual reduction of about 2 per cent, when what is needed is more like 7 or 8 per cent. To hit that target, every sector of the economy has to put its shoulder to the wheel and tough policies will have to be implemented, such as completely refurbishing the housing stock to make it low energy and putting a price on carbon emissions.

Even that won't be enough; we will also require widespread deployment of carbon capture and storage technology (CCS), which is unproven on a large scale, and which opens up another loophole. Instead of pouring money into CCS, advanced economies could pay to plant trees in other countries – usually developing economies – and count this towards their domestic target.

While it is easy to be cynical about governments committing to something they won't be judged on for three decades, there are optimistic noises emerging from climate science. The UK's declaration of net zero has "shifted the dial", says Jim Skea, professor of sustainable energy at Imperial College London, with even North Sea oil and gas companies accepting the need for net zero targets. And a national commitment will be useful for peer shaming at the critical UN climate talks due in the UK in November, says Joeri Rogelj of the Grantham Institute in London.

It still won't be easy. It will still take unprecedented transformation of every aspect of society. But the optimism is rising: we can be zeroes. ▮



Japan: Nature, culture, science

Discover Japan on a 12-day tour taking you to Tokyo, Hakone, Kyoto and Kagoshima

In one of world's most technologically advanced countries, visit leading institutions and explore advances in space travel, robotics and AI, whilst witnessing exceptional landscapes, from snow-capped mountains to hot springs and volcanic islands

Tour highlights include:

- **Talks and walking seminars from *New Scientist* head of features Rowan Hooper**
- **Miraikan Museum of Emerging Science**
- **SCMAGLEV and Railway Park**
- **Toyota Museum of Industry and Technology**
- **City tours of Tokyo and Kyoto**
- **Two bullet train journeys**
- **JAXA space museum**
- **A traditional meal with a geisha**
- **The Sakurajima volcano**
- **Sailing on Lake Ashi**
- **National Museum of Nature and Science**
- **Space Museum TeNQ**
- **Zen temples and Shinto shrines**

No single supplements for the first two solo travellers to book. There are only 15 spaces available on this tour, so please get in touch early to ensure you don't miss out.

Departing:
18 October 2020
12 days for £6,695 (approx $8,499)

To book call +44 1285 601 571 (UK hours Mon to Thu 9-5:30 Fri 9-5 GMT)
Or email newscientist@steppestravel.com

newscientist.com/tours

In partnership with Steppes Travel

SteppesTravel

Editor's pick

More common ground on the changes we need

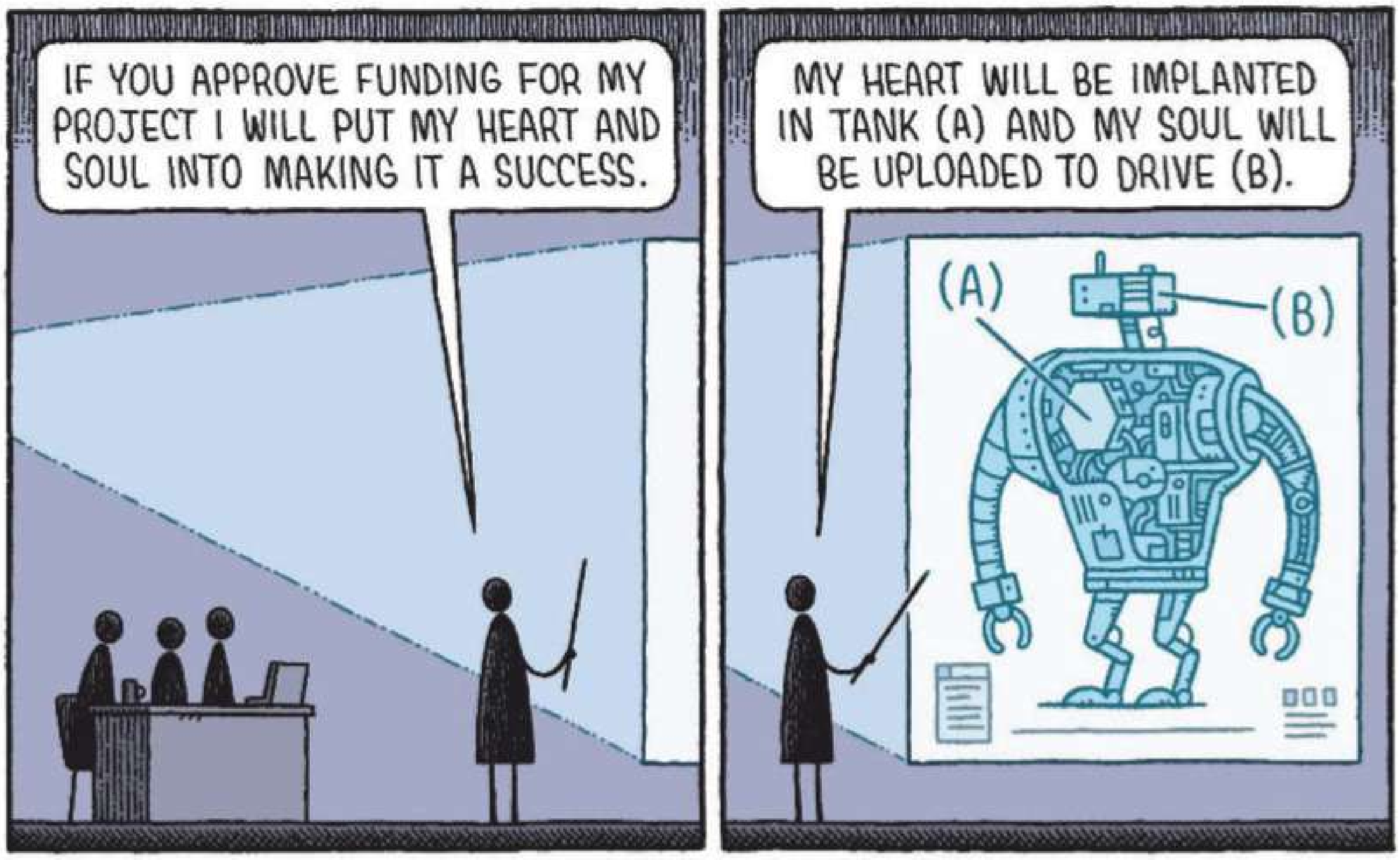
Letters, 21/28 December 2019

From Iain Climie,
Whitchurch, Hampshire, UK

Roger Taylor notes that recycling is one area where common ground can be found with climate change sceptics. There are many more.

Restoring fish stocks, reducing waste, combining conservation with careful usage, using alternatives to fossil fuels, making less use of cash crops, promoting tree growth and use via silviculture and cutting the impact per head of livestock and their overall numbers are examples.

Maddeningly, politicians and other policymakers could have supported these actions in the past 30 to 40 years, since they make sense whether climate change develops as expected or not – and even if temperatures fall following a major volcanic eruption. Further, trees can be good near-term carbon sinks, are a potential source of fuel and have other benefits. As usual, short-termism won out over intelligent win-win policies.


IF YOU APPROVE FUNDING FOR MY PROJECT I WILL PUT MY HEART AND SOUL INTO MAKING IT A SUCCESS.
MY HEART WILL BE IMPLANTED IN TANK (A) AND MY SOUL WILL BE UPLOADED TO DRIVE (B).
(A)
(B)

TOM GAULD for NEW SCIENTIST

Can planting trees combat climate change very much?

Letters, 7 December 2019

From James Fenton,
Clachan Seil, Argyll, UK

Recent letters, like that from Adam Osen, focus on planting trees to help mitigate climate change through their storage of carbon. It may not always work.

Planting trees on open ground may change the reflectivity, or albedo, of land. At higher latitudes this can cause a warming effect, as three-dimensional woodland absorbs more radiation than the essentially two-dimensional open ground that it replaces.

In many places new planting is likely to be targeted at upland areas, which generally possess stratified soils with a high organic carbon content. In the UK there is an order of magnitude more carbon stored in soil carbon than plant biomass. Tree planting on such soils can oxidise this carbon, potentially releasing more than the amount taken up by the trees. And practices such as ploughing land before planting can dry out the soil, causing carbon release. At the other end of the forestry cycle, modern tree extracting machines can similarly churn up the soil.

So it isn't clear to me whether tree planting will benefit the climate. There is also the issue of natural and semi-natural habitats being converted to woodland at the expense of biodiversity.

I believe the best approach would be to leave the extensive tracts of UK upland with a shallow humus layer unplanted, so that over time the soil carbon store builds up and, on level ground at least, goes on to form peat.

Reforesting is a stopgap solution to carbon woes

11 January, p 44

From Martin Murray,
Telford, Shropshire, UK

I appreciate Tom Crowther's research on reforestation, which is vital and urgent. But reforestation is a stopgap solution to climate change while we decarbonise the economy. What if we plant enough trees to stabilise carbon dioxide levels in the air, while still burning fossil fuels? We would end up with a planet that is still warming and has nowhere left for new forests.

Forest restoration is essential – and will help with maintaining biodiversity. But it must be done alongside emissions reductions.

An obstacle to making deniers my friends

11 January, p 21

From Guy Cox, St Albans,
New South Wales, Australia

David Westmoreland and Connor McCormick say the flat-Earthers they meet are savvy about science. They also report flat-Earthers measuring shadow lengths at various latitudes to look for curvature of Earth and coming up with inconclusive results.

The African-Greek scholar Eratosthenes used this method to calculate Earth's circumference before 200 BC. He was correct to within 10 per cent. So much for the flat-Earthers' experimental competence. There may be another explanation. My limited experience of such people leads me to think that many are just contrarians who enjoy the challenge, doubtless honed in school debating societies, of defending the indefensible.

Just when an autonomous car needs you most...

Letters, 18 January

From Anna Zee, Leicester, UK

Will motion sickness be an issue for people deprived of a sense of control in autonomous cars, asks Frank Siegrist. It will. I first heard of this in 2018, at a conference on highly automated vehicles at the University of Warwick, UK. Before we reach full vehicle autonomy, human drivers will need to take over in some circumstances. There is currently, as I understand it, no way of determining whether a driver may be impaired by motion sickness when required to do this.

Reasons why Neanderthals may not have died out

7 December 2019, p 19

From Roger Williams,
Lucerne, Switzerland

You report philosopher Krist

Vaesen arguing that Neanderthals were such a small population that they may have been intrinsically at risk of extinction through a combination of unfortunate circumstances, rather than being actively exterminated or out-competed by *Homo sapiens*.

Researchers could also, given the small size of the Neanderthal population relative to *H. sapiens* incomers, consider a further possibility: that Neanderthals never went extinct as such. Eurasian populations today have 1 to 4 per cent of Neanderthal DNA. It is possible that Neanderthals interbred with *H. sapiens* until, after a few thousand years, there were no "pure" Neanderthals left.

This process would have been accelerated if "mixed" offspring were infertile, except for female children of *H. sapiens* mothers and Neanderthal fathers. This idea is supported by reports that in modern *H. sapiens* neither the mitochondria – passed from mothers to all children – nor the Y chromosomes – passed from father to son – show Neanderthal traces (bit.ly/NS-neanderthal).

The topic is interesting and requires further research. Vaesen is right not to fall into the easy trap of seeing the *Homo* species or subspecies as necessarily in a state of life-or-death competition. At this remove, it is wrong to make assumptions about how the two populations would have seen each other at the time.

The editor writes:

We have discussed the idea that Neanderthals may have become absorbed into modern human populations (25 August 2018, p 7). / And for more on Neanderthal DNA in people today, see page 19.

Ask an AI to explain how an AI made its decision

Letters, 14 December 2019

From Tim Flanders,
New Longton, Lancashire, UK

Paul Bowden is among the many people who are concerned that AI will not be able to reveal its reasoning. Although we should be aware that someone can make decisions without being able to give their full reasoning, or may even answer differently each time asked, I do think there may be a better way to evaluate AI decisions.

We could train another AI to interrogate it, using the same set of variables the original AI was given and varying them slightly on each iteration to infer what "mattered" to the decision maker.

Since computers can repeat the same process over and over again very quickly, this process should be able to ascertain the detail that was important in the decision. It seems to me eminently superior to interrogating humans, who may fear blame.

Don't ignore the personal in evaluating altruism

7 December 2019, p 42

From Frank Lukey,
Penistone, South Yorkshire, UK

I read with great interest Joshua Howgego's discussion of using evidence and reason to maximise the impact of kindness. It reminds me of utility theory in economics.

The usefulness, or utility, of a given outcome depends markedly on the person involved and on their situation. Worse, utility can change significantly over time. We should surely recognise that personal perception lies at the very heart of decisions to donate.

Connecting giver to receiver is important – it often means that much more than money is shared. Human sympathy and interest matter greatly.

For example, building a specific school or clinic for specific recipients not only leads to effective application of funds, it also leads to greater giving. Donors who are personally interested gain an appreciation of the local problems. This can lead to personal trips by skilled builders or those who can offer training in medical matters.

This sort of thing doesn't come from a scientific effectiveness measure alone. Aid agencies surely need to be held to account by some recognised methodology. But don't ignore the personal. A purely scientific approach is rarely an adequate description of the realities of human community.

I still can't ride this big bang bandwagon

4 January, p 20

From Paul Leek,
Willimantic, Connecticut, US

Chandra Prescod-Weinstein asks: are dark matter and dark energy related? Yes: both are imaginary constructs required to paper over the cracks in the "big bang" concept. I find it difficult, as an old physicist, to understand how far this illusion has gone within the physics community.

I remember the astrophysicist Fred Hoyle pouring scorn on the "big bang theory" in 1949. It is a shame that the word "theory" is used in the term, as it was always used to denote an idea which had some definite proof. The "theory", as it stands, looks to me more like a creation by satirical novelist Terry Pratchett than a product of modern physics.

Is no one in the physics or cosmology communities working on alternative scenarios? It seems that every other issue of *New Scientist* has an article outlining the failings of the big bang idea.

How can any serious physicist consider that a large percentage of the material in the universe is something about which we haven't a clue? We now have a big bang bandwagon.

This all reminds me of Lewis Carroll's poem *The Hunting of the Snark*, which warns: "If your Snark be a Boojum… you will softly and suddenly vanish away". I believe the big bang theory is in fact the big bang boojum.

Did we hum a happy tune while we munched leaves?

11 January, p 34

From Steve Wain,
Horkstow, Lincolnshire, UK

A serendipitous concurrence of events has set me thinking. In your article on breathing and better memory and sleep you say that humming sets up swirls of air in the sinuses, which boost the production of nitric oxide 15-fold. And recently there was coverage of the finding that gorillas "sing" while they eat (5 March 2016, p 18).

The humming-like sounds they make certainly seem to be generated in the sinuses. Bearing in mind nitric oxide has an effect on smooth muscle tissue, such as that in the gut, could this be an aid to effective digestion?

It is tempting to think that we, too, may have evolved, as social arboreal primates, a musical mechanism that also offered such digestive benefits as well as effective social communication, pre-language. This may even add weight to the argument that music predated language.

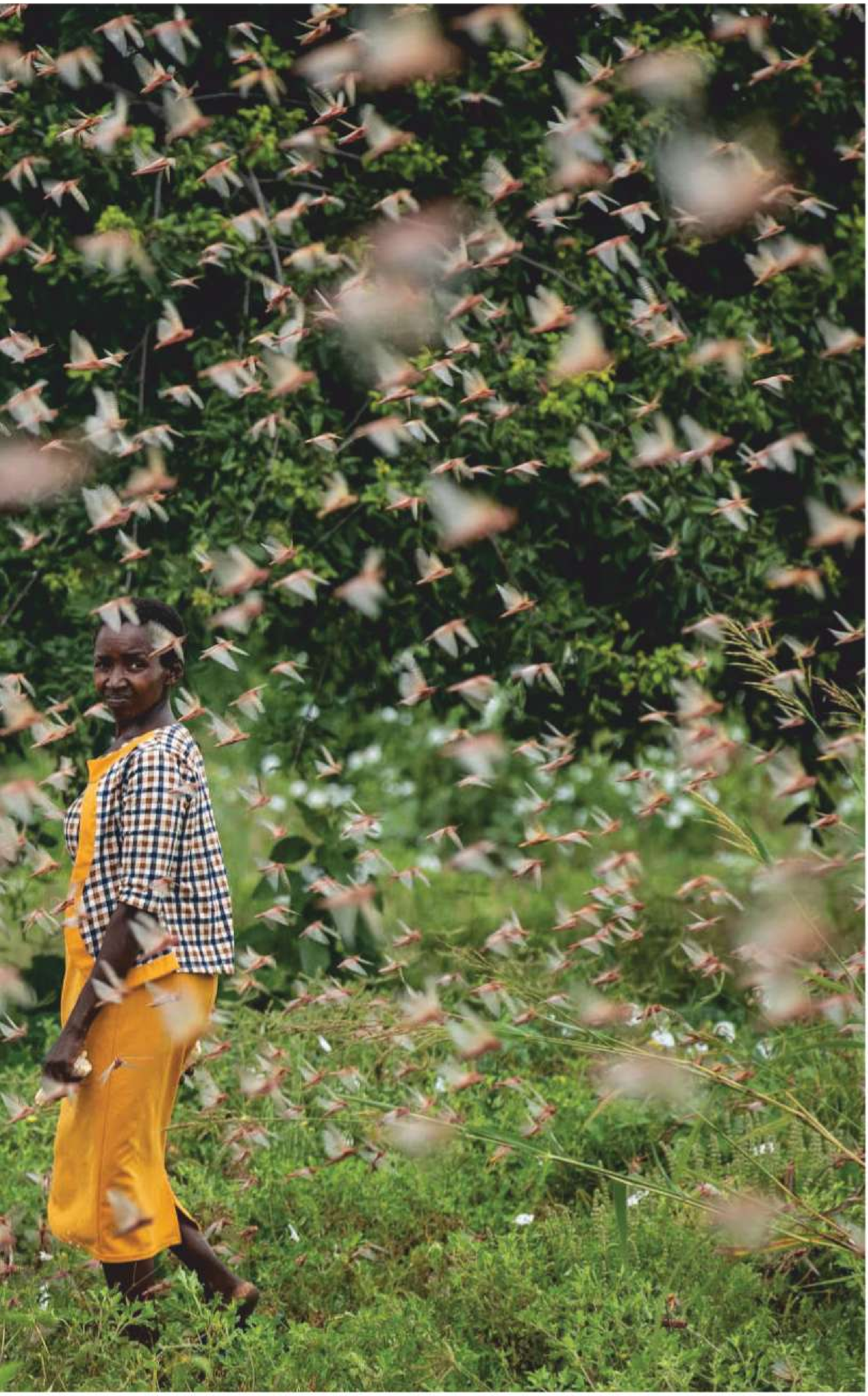
If nothing else, it could also explain the way music can so easily elicit visceral responses. Is there any research into how such a link, forged in our evolutionary past, may have then become adapted subsequently? ▮

For the record

▮ **Our comment on George Monbiot's statement that the "land efficiency" of Solar Foods protein production from hydrogen and oxygen is roughly 20,000 times that of conventional agriculture, based on the area occupied by the factory, is only that it isn't relevant: he also uses Solar Foods' figure that the area of the factory, plus solar panels to power it, is 10 times smaller than equivalent fields, which is relevant (18 January, p 10).**

Want to get in touch?

Send letters to New Scientist, 25 Bedford Street, London WC2E 9ES or letters@newscientist.com; see terms at newscientist.com/letters



Swarm of death

Photographer **Ben Curtis**
Agency **AP Photo**

THIS farmer can only watch in dismay as locusts in swarms of biblical proportions devour her crops outside Katitika village in Kenya. It is the worst invasion by desert locusts (*Schistocerca gregaria*) in decades to hit Kenya, Ethiopia and Somalia, destroying crops in an area already facing food insecurity. Somalia has declared a national emergency.

Hundreds of millions of locusts are forming swarms bigger than cities. Stopping them will require the aerial spraying of pesticides, which could cost $70 million, says the United Nations Food and Agriculture Organization (FAO).

It fears locust numbers could grow some 500-fold when rains arrive in March, bringing new vegetation. An adult can eat its body weight in food daily, and a Paris-sized swarm can eat as much in a day as half the population of France, according to the FAO.

Desert locusts are usually solitary, but rain after drought can cause a surge in vegetation, and locust breeding. As the wingless nymphs, known as hoppers, get crowded together, the stimulus of frequent physical contact triggers changes to their colour and behaviour. Hoppers change colour as they become gregarious. Flying adults also change colour, turning pink if immature or yellow if mature. The locusts here look immature, so can't yet produce a new generation.

Chris Simms

Play the realism card on race

Let's welcome a new book that takes apart the persistent race myths plaguing society and helps us fight back against "everyday racism", says **Layal Liverpool**

Book

How to Argue with a Racist: History, science, race and reality
Adam Rutherford
Weidenfeld & Nicolson

GUY SMALLMAN/GETTY IMAGES

Fighting racism means tackling the most entrenched stereotypes

I AM black and mixed-race, but it remains unclear to me whether these are social identities or biological classifications. Luckily, I can turn to Adam Rutherford's latest book, *How to Argue with a Racist*, to reveal the current scientific understanding of race, ancestry and genetics. It also tells us how to argue effectively against the idea that certain populations of people are biologically inferior.

From the beginning, Rutherford is clear that although he uses the term "race" frequently, he does so only because the word is widely used: it isn't scientifically valid, yet it exists so must be addressed. "Race is a social construct. This does not mean it is invalid or unimportant," writes Rutherford.

How to Argue with a Racist's strongest suit is to encourage a general conversation about race, informed by the latest science on the reality and origins of racism. Researching ethnicity has often been career death, but Rutherford says scientists shouldn't shy away from the field. Nor should writers, to judge by his mission.

For many, race is a cry for identity and belonging. In 2018, when groups of neo-Nazis in the US "chugged" milk to supposedly demonstrate their superior, genetically encoded ability to process lactose, they were trying to assert their white identity, writes Rutherford.

He rather undermines such an assertion by revealing that the gene mutations that enable lactose processing aren't unique to people of European descent. They also exist today in Kazakhs, Ethiopians, Tutsi, Khoisan and in many places where dairy farming took off as part of agriculture.

Chugging milk is a theatrical gesture, but as Rutherford points out, we increasingly turn to ancestry and genetic testing to reaffirm our human tendency to seek meaning and identity.

> "The field of human genetics has a dark history, but it has also demonstrated the falsity of race"

I can relate to this. My surname, Liverpool, comes from an ancestor on my father's side, forcibly shipped from West Africa to the Caribbean via Liverpool, UK, during the transatlantic slave trade. But as Rutherford points out, the number of children produced by sex between enslaved peoples, and between the enslaved and their owners, makes it virtually impossible for a genetic test to establish an African country of origin for the descendants of slaves.

Instead of arguing against the logic of marrying identity to ancestry, Rutherford elegantly uses a bit of mathematics to show how our whole way of thinking about ancestry is wrong.

He assumes generational time is 25 years and that the number of ancestors for each person in every generation has doubled. So we each have two parents, four grandparents, eight great-grandparents, and so on. In 500 years, or 20 generations, that is 1,048,576 ancestors. Go back 1000 years, and each of us has more than a trillion ancestors: 10 times more people than ever existed.

The notion of a family tree isn't the most scientifically accurate metaphor, he writes, because trees only ever branch, but family trees contain loops, with the same person appearing at multiple positions in the tree, for example, as a result of first cousins having children. Understanding that we are all more closely related to one another than we think is a pretty strong argument against racism.

Is any of this enough to convince hard-liners? Maybe not. As Rutherford writes: "The commercial genetic tests remain scientifically unconvincing. Regardless, the utility of consumer genetic testing is now a major and significant part of white supremacy discourse."

But in many ways *How to Argue with a Racist* isn't really about arguing with hard-liners. Its target is the surprisingly prevalent set of racist beliefs, from men of certain groups having larger or smaller penises than average to people from different racial groups being more or less intelligent than average. "The way we generally speak about races does not align with what we know about those innate differences between people and populations," says Rutherford.

For example, the largest study of penis size, including more than

15,000 men, found no evidence that the organ's length or girth correlates with any particular population, racial category or ethnicity, while intelligence is a complex trait influenced by a score of genes and their interaction with our environment.

Rutherford hunts widely to account for the persistence of such racist ideas. But in the end, he faces down the biggest issue at the core of many of these racist stereotypes: is race truly a biological classification?

We are constantly told that it is a social construct, but scientists muddy the waters by appearing to contradict this as they perhaps carelessly mention both race and ethnicity in their research papers.

Rutherford is clear that the majority of geneticists think genetic differences between ethnic groups are meaningless in terms of behaviour or innate abilities. But he also acknowledges the contradiction because scientific papers are still published in which genes for complex traits like intelligence seem stratified along racial lines.

Race science is pseudoscience, but genetics and evolutionary research are inextricably tied up with race, and are often used by racists to justify themselves. Rutherford accepts that the field of human genetics has a dark history, "founded by racists in a time of racism", but also argues that genetics "has demonstrated the scientific falsity of race".

He writes that scientists' reluctance "to express views concerning the politics that might emerge from human genetics is a position perhaps worth reconsidering". After all, he argues, those who misuse science for ideological ends show no such restraint, and embrace modern tech to spread their messages. ▮

Robots going rogue

Star Trek's new spin-off explores what happens when tech backfires, finds **Simon Ings**

TV

Star Trek: Picard

Amazon Prime Video

STAR TREK first appeared on television on 8 September 1966. It has been fighting the gravitational pull of its own nostalgia ever since – or at least since *Star Trek: The Next Generation* began 21 years later.

***The Next Generation* was the series that gave us shipboard counselling (a questionable idea), a crew that liked each other (a catastrophic idea) and Patrick Stewart as Jean-Luc Picard, who held it all together, pretty much single-handedly.**

Now Picard is back, retired, written off, an embarrassment, a blowhard. And *Star Trek: Picard* is a triumph, praise be. But something bad has happened to the "synthetics" (read: robots) who, in the person of Lieutenant Commander Data (Brent Spiner, returning briefly), promised so much. Any machine that can do what these robots are expected to do will be able to down tools – or worse. *Picard*'s take isn't yet clear, but the consequences of all the Federation's synthetics going haywire is painfully felt.

The Federation has all but abandoned its utopian remit, and is now just one more faction in a fast-moving, galaxy-wide power arena (echoes of Trump are entirely intentional). Can Picard, the last torchbearer of the old guard, bring it back to virtue? One jolly well hopes so – and not too quickly since *Picard* is a great deal of fun.

There are already exciting novelties, although the one I found most intriguing may just be an artefact of getting the show off the ground. Picard's world – troubled by bad dreams as much as it is enabled by world-shrinking technology – is oddly surreal, discontinuous in ways that aren't particularly confusing but can jar.

Is the Star Trek franchise finally getting to grips with the psychological consequences of its mastery of time and space? Or did the producers shove as much into the first episode to get things rolling? The latter seems likely, but I can hope.

The new show bears its burden of twaddle. The first episode features a po-faced analysis of Data's essence. No, really. His essence.

How twaddle became a key part of *The Next Generation* is a mystery: the first series never felt the need for it. Yet, like a hold full of tribbles, twaddle now seems impossible to shake.

But why cavil? Stewart brings a new vulnerability and even a hint of bitterness to grit his seemlessly fluid recreation of Picard, and the story promises an exciting and devastating twist to the show's old political landscape. Picard, growing old disgracefully? Oh, make it so! ▮

2019 CBS INTERACTIVE, INC.

Patrick Stewart reprises Jean-Luc Picard, now retired and distinctly written-off

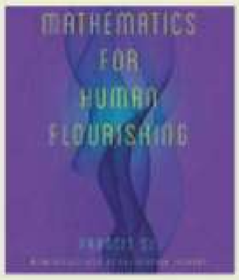
Don't miss

Last chance

Maternality, the second instalment of a two-part art exhibition about the politics of mothering, focuses on the childbearing body. Ends on 15 February at Richard Saltoun Gallery in London.

Visit

Orchids, the 25th annual orchid festival at London's Kew Gardens, opens on 8 February. It highlights the wildlife and culture of some of Indonesia's 17,504 islands, and includes a whimsical volcano made of flowers.



Read

Mathematics for Human Flourishing (Yale University Press) by Francis Su weaves parables, puzzles and personal reflections to show how mathematics meets basic human desires and builds virtues that help us all flourish.

TOP:KIRSTEN JUSTESEN; COURTESY OF RICHARD SALTOUN GALLERY, LONDON. PHOTO BY BEN WESTOBY. JEFF EDEN/RBG KEW.

The science fiction column

Swipe left or right for everything

Turning our cities into the corporate machines envisioned by two new works of speculative fiction offers unexpected horror and humour. **Sally Adee** explores some fraught urban futures

Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee

Books

How to Run a City Like Amazon, and Other Fables

Edited by Mark Graham, Rob Kitchin, Shannon Mattern and Joe Shaw

Meatspace Press

QualityLand

Marc-Uwe Kling

Orion

Sally also recommends...

Podcast

Personal Best

Andrew Norton and Rob Norman

CBC

This is a self-improvement show for people who don't like self-improvement. As Norman says: "These little things that we want to change, and that annoy us, actually make us interesting, nuanced creatures."

QI YANG/GETTY IMAGES

Turning a city "smart" is an alluring prospect, for some

IN STARBUCKS CITY, you can apply to have a pothole filled, just like in any other city. Just specify the size of your hole (Maltesa, Sharpe or Labradoro) and be sure to check whether your neighbourhood requires your asphalt to be ethically sourced.

In recent years, it has become a truism among policy-makers that cities should be optimised in the way corporations are. Turning a city into a "smart city" is an alluring prospect. It pushes inefficient government bureaucracy out of the way and replaces it with streamlined corporate governance. But to what end?

Two new works of speculative fiction take that question very literally, and their vision of the efficiency endgame shares more DNA with horror than with science fiction, albeit cut with farce.

Because what do we mean by optimising? Whose priorities are reflected in that word? *How to Run a City Like Amazon, and Other Fables* imagines life if a whole city were run by one of 38 megacorps even now insinuating their way into our lives. One of the co-editors, Mark Graham, an internet geographer at the University of Oxford, asked some academics to write speculative stories or essays about living according to corporate leadership principles espoused by companies from Apple to Pornhub.

The underlying question here is what could possibly go wrong? It is posed, one imagines, with a certain degree of glee.

> "Imagine life if a whole city were run by one of the megacorps even now insinuating their way into our lives"

"We are beyond the point where we can use human frailty as an excuse," writes Sarah Barns in one stand-out story, "So You Want to Live in a Pivot City?". She examines a takeover of a city's carbon economy in the style of Alphabet's urban innovation arm, Sidewalk Labs.

The way you spend your day is no longer your business, and every choice is measured. Meanwhile, in Tinder City, you swipe left or right for everyone and everything, from sex to teachers and civil servants.

Some pieces are derivative, but among the predictable notes of *Black Mirror* and *Inception* lurk strange poetry and unexpected horror: in the city run by Acxiom (one of the world's biggest data brokers), you get the treatment you deserve – according to your data.

What kind of humans would be able to survive there? Marc-Uwe Kling's satirical novel *QualityLand* nurtures that question into full bloom. In QualityLand, every citizen is named after parental careers. Also, everyone rates everyone on every interaction, from work to sex. Enter Melissa Sex-Worker, icily determined to improve her lot. She is aggressively pursuing a higher score because a higher social credit, as in China, creates a more frictionless life.

We are already in the pupal state of such a world. Some people on Instagram get real-life fillers and surgery to replicate the most engaged-with facial contours, conferred by the app's Facetune filter. The denizens of LinkedIn (a network of muscular, joyless efficiency) publicise morning routines meant to turn them into perfect entrepreneurs: "4.30: get up. Bulletproof coffee. 5 am: gym while I learn a new language".

Meanwhile, in QualityLand, robots with bugs get scrapped because fixing them is against the law. But one guy keeps old robots: left to their own devices, the bugs evolve into distinct personalities.

You just watch: in our lifetime, robots will be the only ones smart enough to help us rise above the drive to automate, optimise and homogenise us into robots. ▮

Land of fire and ice

Majestic landscapes, erupting geysers, hot springs and bubbling mud

Departing:
31 October 2020, 7 November 2020
8 days for £2,249 (approx $2,855)

Iceland is one of the world's most intriguing destinations for science enthusiasts. Accompanied by leading academic volcanologist Tamsin Mather, you will go on an eight-day volcanic and geological adventure around this fascinating island.

Unforgettable experiences on this tour include:

- **A chance to see the aurora borealis during the evenings.**
- **Visit geological wonder Þingvellir National Park.**
- **A trip to the elegant Seljalandsfoss waterfall where you can walk behind the plummeting torrent.**
- **Superjeep safari tour of Hvolsvöllur.**
- **A walk on Europe's biggest ice cap, Vatnajökull.**
- **Swim in the geothermal waters of the Secret Lagoon.**
- **Investigate Reykjanes Peninsula to see where two tectonic plates meet.**

Due to high demand we have two departure dates on this tour with only 15 places available per tour. We expect places to be booked quickly, so get in touch early to secure yours.

To book call +44 203 308 9917 (UK office: Mon-Sun 9am to 5.30pm GMT)
Or email groupsuk@intrepidtravel.com

newscientist.com/tours

In partnership with Intrepid Travel

INTREPID

ABTA
ABTA No.Y0766

A
TCR
HAPPY HOUR
eX
Ne
BE
CRIMSO
a
U
C
PU
F
b
R
M
A
B

Who invented the ABCs?

It has long been assumed that Egyptian scribes created the first alphabet. That's not the whole story, finds **Colin Barras**

AMENEMHAT III is one of Egypt's lesser-known pharaohs. He made pyramids, but not on the scale of Khufu's at Giza. He commissioned many artworks, but none that survive match the opulence of Tutankhamun's gold mask. He mounted military expeditions, but not with the success of Thutmose III, who built a vast empire. Still, Amenemhat has one claim to fame. Under his rule, a technology emerged that is more impressive, valuable and pervasive than any of these legacies: the alphabet.

The alphabet was a revolutionary way of recording information. But it is more than just a writing system. In a recent book, Philippa Steele and Philip Boyes at the University of Cambridge describe it as an "icon of culture". Today it is so central to education in most countries that children can often recite it long before they have learned to read or write. Beyond the familiar ABC, a variety of alphabets are used to write in many languages, from Russian to Arabic. But all trace back to one common ancestor.

The story of that first alphabet has long been a mystery, but over the past 25 years we have made enormous progress towards pinpointing when and where it was invented. Most astonishing, the consensus today is that the alphabet didn't emerge from a state-sponsored initiative as was long believed. Instead, its originators were probably far removed from the ancient world's elites. Paradoxically, they may even have been illiterate. "No trained Egyptian scribe would write in the way these geniuses wrote," says Orly Goldwasser at the Hebrew University of Jerusalem, Israel. "He would be ashamed to do so."

By 3800 years ago, when Amenemhat III ruled, writing had already been around for more than 1000 years. Two systems had become particularly influential: cuneiform, originating in Mesopotamia in south-west Asia, and Egyptian hieroglyphics. It was the latter that inspired the inventors of the alphabet, which still carries faint echoes of its hieroglyphic heritage. Our letter M, for instance, has the crests and trough of a water wave, the hieroglyphic sign from which it emerged. Although most of the letters of the alphabet weren't exactly new, the way they were repurposed certainly was.

Egyptian hieroglyphs generally represented syllables or full words. The alphabet uses a different approach. All letters represent phonemes, the indivisible elementary particles from which spoken languages are built. The word "pen", for example, is just one syllable but contains three distinct phonemes, each represented by one letter. There were some phonemic elements in earlier writing systems, but the alphabet was entirely phoneme based. That was revolutionary.

It may seem like a small distinction, but it makes a huge difference to the way the alphabet worked compared with hieroglyphics. The Egyptians needed hundreds of distinct hieroglyphs to represent individual words. Most languages comprise just a few dozen phonemes, however. As a consequence, all of the 40 or so known proto-alphabetic texts use the same 20 or so symbols, or letters (see "The first alphabet", page 36).

As far as we know, this original alphabet wasn't used to write Egyptian words, but the words of one or more Semitic languages, a group of languages spoken, at that time, by various populations living in the Middle East and Turkey. This suggests the alphabet was a cross-cultural invention. "It makes sense to see this coming out of a close association of Egyptian and Semitic speakers," says John Darnell at Yale University. But in what context the two groups came together to invent the alphabet – and exactly when – wasn't clear for most of the 20th century. Archaeologists first unearthed examples of the early alphabet in 1905, but so little else was found in the following decades that people lost interest in the alphabet's origins. Then, in 1995, Darnell made a discovery that rekindled the flame.

While working at the desert site of Wadi el-Hôl, a few tens of kilometres north-west of Luxor (the ancient Egyptian city of Thebes), Darnell's team analysed two alphabetic

›

BACKHANDING/GETTY IMAGES
MARTIN RUEGNER/GETTY IMAGES
FLORIAN MOSER/PLAINPICTURE
DARWIN RAMOS/EYEEM/GETTY IMAGES
CHOI LAI YEE JOEY/EYEEM/GETTY IMAGES

HOW WE WRITE TODAY

The alphabet was born about 3800 years ago. After a slow start, it has produced dozens of offspring. Arguably the most important divisions happened between 3000 and 2000 years ago. Near the beginning of this period, the Phoenician alphabet – a direct descendant of the first one – gave rise to the Greek and Aramaic alphabets. The Greek alphabet then led to a huge variety of forms, from the Cyrillic family used in south-east Europe and northern Asia to the Latin/Roman family that includes English, German and French. The Aramaic alphabet, meanwhile, blossomed into a group that includes the Hebrew and Arabic alphabets. It probably also gave rise to the Brahmi script, another distinct type of alphabet that is itself the parent of dozens more used across south and South-East Asia.

Aside from the alphabet, there are two other modern writing systems. In the first – of which Chinese text is the only real example still in use – signs represent full words. In the other, signs represent syllables. Japanese uses many Chinese "word" characters, but has two other writing systems based on syllable signs. The few other syllable-based systems include the Cherokee one used in the south-east US.

The variety and global dominance of the alphabet isn't necessarily a sign of its superiority to other writing systems, says Amalia Gnanadesikan, recently retired from the University of Maryland. In some parts of the world, alphabets have been foisted on people by empire builders, she says. For instance, they are used across north Asia, Africa and the Americas because of Russian and western European expansionism.

The fact that alphabets use a smaller set of characters than other writing systems isn't entirely beneficial either, says Gnanadesikan. It means words must be written using combinations of several symbols. Take the phrase "dog bites man". Someone learning Chinese has to understand just three signs – rather than 11 letters – to read and write the sentence. "So you get a very rapid ability to translate what you're learning into use," she says. Moreover, children in Japan learn the hiragana syllable-based writing system so easily that they can often start reading aged 3.

> **"Good inventions tend to take root fast, so why did the alphabet seem to languish for 600 years?"**

inscriptions carved into rock. Although still indecipherable, the style of the letters suggests many emerged from a very particular type of Egyptian hieroglyphics called hieratic. This was a significant discovery. Formal hieroglyphics altered little as time passed, but hieratic did change. And the inscriptions looked like a style of hieratic used 3800 years ago. "It's pretty incontrovertible that the inscriptions date to the end of the 12th dynasty, during the reign of Amenemhat III," says Darnell. That makes them among the oldest alphabetic inscriptions found.

Most scholars agree that this is currently our best guess for when the alphabet was invented. The Wadi el-Hôl carvings also hint at how it was invented. The site was frequented by the Egyptian army, and military recruits were a cosmopolitan bunch. "You'd have had all sorts of people: Nubians, Egyptians, people from what we'd refer to as Libya, people from south-west Asia – it was a real melting pot of people and languages," says Darnell. Military expeditions also required scribes to read and write dispatches, so he imagines a scenario in which those professional scribes sat down with their military colleagues from south-west Asia and helped them invent the alphabet. "I'd say it has to come out of some interaction," he says. "And whoever came up with those signs was probably literate in Egyptian hieratic."

Darnell and his colleagues published their findings in 2006. Although widely accepted as landmark work, it wasn't the end of the story. For a start, it highlighted a real puzzle. As far as we can tell, the alphabet wasn't embraced for state business until 3200 years ago. Brilliant inventions tend to take root fast, so why did the alphabet seem to languish for 600 years?

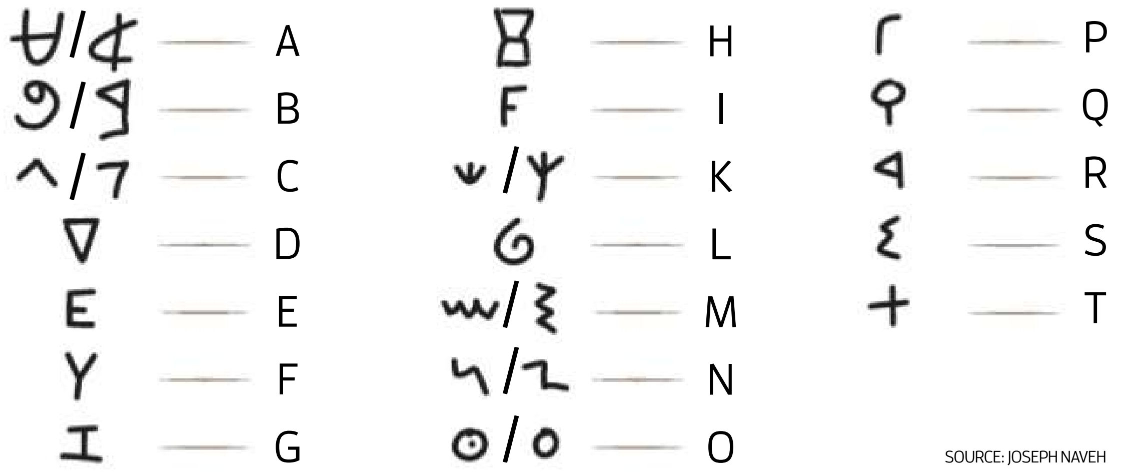
One surprising suggestion is that the literati didn't consider it to be superior to their traditional scripts. "We're conditioned to thinking about writing in terms of efficiency," says Boyes. From this perspective, cuneiform and hieroglyphics must be poor systems because they employed hundreds of signs, each potentially having multiple meanings. But scribes valued this complexity, in part because it left room for creativity – enabling them to make visual puns, for instance. "You can switch things around to show how clever you are," he says. At the same time, ancient writing systems were crystal clear in their meaning. The earliest versions of the alphabet were less so. For instance, most didn't fully represent the vowels of the spoken language.

Hidden history

However, another possibility is emerging: the alphabet didn't fail to take off, its early history has simply been hidden, until now. In 2015, Ben Haring at Leiden University in the Netherlands described a 3450-year-old chunk of pottery unearthed a few decades ago in a tomb near Thebes. He soon realised the text was unusual. The Egyptian hieratic and hieroglyphic writing looked like one, or possibly two, mnemonics – or memory aids – spelling out the first few

The first alphabet

Alphabetic texts first appeared around 3800 years ago. The oldest share dozens of symbols but the record is incomplete. However, by around 3200 years ago, something resembling today's ABC was emerging



SOURCE: JOSEPH NAVEH

HEMIS/ALAMY STOCK PHOTO

Texts engraved at Serabit el-Khadim in Egypt (left) could be the root of the Phoenician alphabet, shown on a 2700-year-old tablet (below)

TRUSTEES OF THE BRITISH MUSEUM

letters of the alphabet in alphabetical order. A modern version might read "Albert Bought Custard Doughnuts". Aaron Koller at Yeshiva University, New York, argues that this is a key discovery. Thebes was Egypt's capital at that time, he says. And this fragment of pottery suggests that scribes in the metropolis wanted to learn the writing system apparently invented by their provincial military colleagues 350 years earlier. That might seem like quite a lag, but although Wadi el-Hôl was close to Thebes, in cultural terms it was a world away, visited rarely by Egypt's elites.

Even if the alphabet was catching on, the Egyptian state didn't abandon hieroglyphics. Koller thinks he knows why. The clue, he believes, lies in a collection of 3500-year-old clay tablets documenting formal state business in southern Mesopotamia, more than 1000 kilometres east of Egypt. The text is in cuneiform, but when Stephanie Dalley at the University of Oxford examined the tablets, she discovered something intriguing. On the edge of four of them were short alphabetic inscriptions. Mesopotamian scribes stored cuneiform tablets on shelves in rows, like books in a modern library, says Koller. That makes text on the edges important because it is all that is visible to anyone navigating the archive. Like their counterparts in Egypt, he thinks, Mesopotamian scribes were compelled by tradition to use the ancient writing systems to document official business. But for unofficial, private work – like writing these "spine notes" – they chose to use the alphabet because they found it quicker to write and read.

Dalley is sceptical about Koller's idea, however. "I do not think the evidence bears the weight of his deductions," she says. Christopher Rollston at George Washington University in Washington DC also advocates caution because the tablets lack provenance, so it is unclear whether they were archived with the alphabetic inscriptions exposed. In fact, he doubts that scribes used the alphabet widely in its first 600 years. Professional writers typically standardise their writing systems, he says, but there is nothing standard about the way alphabetic texts were written before 3200 years ago. Some read right to left, others left to right, and yet others top to bottom. Even the orientation of letters within words wasn't fixed. "If scribes were using this fairly widely for their own purposes, we would expect a modicum more standardisation," he says.

Goldwasser goes even further. She thinks one reason scribes failed to adopt the alphabet is that they played no part in creating it. In fact, she believes it originated not at Wadi el-Hôl, but at Serabit el-Khadim in the Sinai peninsula of north-east Egypt, where alphabetic inscriptions found a century ago have now been dated at about 3800 years old.

Serabit el-Khadim was once a centre of turquoise mining, employing Semitic-speaking Canaanites from the Middle East to extract the gemstone. Goldwasser's idea is that these illiterate miners saw Egyptians writing dedications to the gods and wanted in on the action. Given their lowly status, they were never going to persuade Egyptian scribes to teach them hieroglyphics. So they improvised. They assigned new meanings to signs in the hieroglyphic texts so they could record their Semitic language phonetically – and created the alphabet. The Serabit el-Khadim alphabetic inscriptions are crudely executed, with letters of different sizes, Goldwasser notes, suggesting they were written by people with no formal training. Egyptian scribes would never be so clumsy in their work, she says.

Koller concedes that the writing is crude, but still thinks it makes more sense to see the alphabet as an invention from within Egypt's literate elite. However, he also notes that early alphabetic texts are presented in an unbroken stream, whereas hieroglyphic writing incorporated signs to indicate where words end. "So, if the inventors of the alphabet knew Egyptian, they consciously omitted something that's clearly useful," he says.

Rollston thinks it possible that Canaanitic miners played a key role in the alphabet's invention. But he questions whether they were completely illiterate. Goldwasser herself has found evidence that some Canaanites used Egyptian hieroglyphics in the traditional way, although their writing is littered with basic errors. However, she argues that these literate Canaanites were tribal leaders who wouldn't have mingled with the illiterate miners.

Whoever invented the alphabet, they never lived to realise the importance of their creation (see "How we write today", left). Indeed, it is still a mystery exactly why the alphabet ultimately replaced other writing systems. It is tempting to link it with a region-wide collapse of civilisations 3200 years ago, the cause of which is still unknown. But the alphabet was beginning to rise to dominance along parts of the eastern Mediterranean coast before that. "To be honest, I think that it's more of an accident than anything," says Steele.

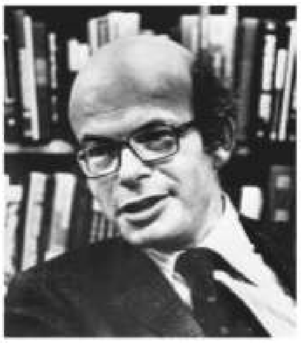
Whatever the reason, the alphabet did become more common as the Bronze Age ended around 3200 years ago. In a very literal sense, written history had changed forever. ■

Colin Barras is a writer based in Ann Arbor, Michigan

ZODEBALA/GETTY IMAGES

"Insane places"

An iconic experiment devastated the field of psychiatry – and has lingering effects today. But it wasn't all it seemed, says **Susannah Cahalan**



BETTMANN/GETTY IMAGES

The credibility of psychiatry was in tatters after David Rosenhan's paper came out in 1973

ON 6 February 1969, David Lurie told a psychiatrist at Haverford State Hospital in Pennsylvania that he had been hearing voices. "Hollow", "empty" and "thud", they said.

The voices were the only symptom experienced by the otherwise healthy 39-year-old copywriter. After an in-depth interview, in which Lurie was asked about his family life and two children, he was diagnosed with schizophrenia and hospitalised.

Yet all was not as it seemed. David Lurie didn't exist. This was, in fact, an alias for psychologist David Rosenhan of Stanford University in California, who went undercover with seven other "pretenders" to test whether psychiatric staff could distinguish sanity from insanity.

Published in 1973, his study contributed to an erosion of public faith in psychiatry, a mistrust memorably portrayed in the 1975 film *One Flew Over the Cuckoo's Nest* starring Jack Nicholson. Rosenhan's work held up for scrutiny the often harmful nature of psychiatric hospitals and galvanised a growing movement to shut the large ones and replace them with smaller, community-based mental health centres. In its wake, "psychiatrists looked like unreliable and antiquated quacks unfit to join in the research revolution", says psychiatrist Allen Frances, formerly at Duke University School of Medicine in North Carolina.

Rosenhan's paper was "one of the most influential pieces of social science published in the 20th century", says sociologist and historian Andrew Scull at the University of California, San Diego.

But it wasn't all it seemed. After spending six years investigating Rosenhan and his famous work, I believe he may have carried out a second deception, the effects of which are still being felt in psychiatry today.

Rosenhan wasn't the first person to infiltrate a psychiatric hospital and expose its horrors. Journalists, writers and other psychiatrists had previously done the same – but none with such rigour, in such numbers and in such an attention-grabbing way. Published by the journal *Science*, Rosenhan's paper "On Being Sane in Insane Places" exploded onto the scene "like a sword plunged into the heart of psychiatry", as one article written three decades after its publication observed.

The experiment, as Rosenhan described it, went as follows: eight men and women with no history or symptoms of mental health problems, including himself, presented at 12 psychiatric hospitals across the US, claiming to hear voices that said "thud, empty, hollow". The rest of their personal histories (save for a few biographical adjustments for privacy reasons) remained intact.

All of the participants were diagnosed with a mental health condition, seven with schizophrenia and one with what is now known as bipolar disorder. Once admitted into hospital, they dropped their hallucinations and behaved as they normally did, or as normally as being in hospital allowed. Yet in each case, clinicians viewed their behaviours through the prism of their presumed condition. When one took research notes on the activities of the ward, for example, nurses reported that the "patient engages in writing behavior", according to Rosenhan's paper.

"How many patients might be 'sane' outside the psychiatric hospital but seem insane in it – not because craziness resides in them, as it were, but because they are responding to a bizarre setting?" Rosenhan wrote in his paper.

During these hospitalisations, which lasted between seven and 52 days, some 2100 psychoactive drugs were administered to the participants. All were eventually released, although against medical advice and with their diagnoses labelled as "in remission". "We now know that we cannot distinguish insanity from sanity," Rosenhan concluded.

The experiment was published at the height of the anti-psychiatry movement, at a time when psychiatrist Thomas Szasz wrote that mental illness was a "myth" and psychiatrist R. D. Laing claimed that people with schizophrenia were the sane ones in an insane world. Sociologist Erving Goffman exposed how similar psychiatric hospitals were to

Many psychiatric hospitals were closed as mental health care shifted to communities

prisons in his book *Asylums*, while pop culture spread fear and distrust. Meanwhile, the field faced an internal reckoning as it moved away from Sigmund Freud's psychoanalysis.

By the late 1980s, nearly 80 per cent of all introduction-to-psychology textbooks included Rosenhan's study. Despite virulent criticism from psychiatrists, who claimed when the study was first published that it was misleading and unscientific, it is still presented uncritically in many textbooks today.

Beyond the original nine-page paper in *Science*, which largely focuses on Rosenhan's experience – the bad food, boredom, pacing, the neglect and even abuse of fellow patients he witnessed – scant public information exists about the study. The eight participants never revealed themselves, and Rosenhan wrote nothing further on the topic before his death in 2012. But in the course of my research, I gained access to a trove of documents he left behind – decades of correspondence, diary entries and even an unpublished book on the experiment – and interviewed his family and hundreds of friends and colleagues.

It quickly became clear that some things didn't match up. In Rosenhan's files, I found his Haverford Hospital medical records, which presented an entirely different portrait to that in his paper. One of the foundational principles of "On Being Sane in Insane Places" was that all of the pseudopatients presented with just one symptom: voices that said "thud, empty, hollow". Rosenhan didn't follow his own script.

The admitting psychiatrist Frank "Lewis" Bartlett wrote that David Lurie was so disturbed by the voices that he had put copper over his ears – an almost cliched example of the "tinfoil hat delusion" commonly reported by people experiencing serious mental health problems. "He has felt that he is 'sensitive to radio signals and hear[s] what people are thinking'," Bartlett wrote. Hallucinations and disturbances in thought patterns, particularly believing you can hear or control other people's thoughts, are considered key symptoms of schizophrenia, so would have contributed to his misdiagnosis.

> **"He concluded that it was impossible to distinguish insanity from sanity"**

Suspicious symptoms

Rosenhan also claimed that his wife "did not know how disturbed and helpless and useless" he was, that he had "thought of suicide" and believed that "everyone would be better off if he was not around". Such ideation and threats of self-harm would provide strong grounds for immediate and necessary hospitalisation. "To not hospitalise such a patient would be professionally unethical, and, in almost every circumstance, malpractice," says Michael Meade, chairman of psychiatry at Santa Clara Valley Health and Hospital System in San Jose, California. Intentionally or not, Rosenhan had served up a realistic characterisation of a man experiencing something more serious than the one-symptom portrait of illness his pseudopatients were supposed to describe.

The discovery of such inconsistencies prompted me to try to track down the other pseudopatients who participated in the study. I found the first with relative ease, thanks to a stray handwritten note on an outline for Rosenhan's unpublished book, which mentioned the last name Underwood.

This led me to Bill Underwood, a retired software engineer living in Austin, Texas, who had volunteered to be a pseudopatient while taking Rosenhan's psychopathology seminar during his graduate studies at Stanford. Underwood described the seven days he spent at what was then Agnews State Mental Hospital in Santa Clara, California, as harrowing – he was medicated, misdiagnosed and mistreated. He says he was hardly prepped for his undercover role, and that Rosenhan told him nothing about data collection or how

›

to interact with the patients or staff. In fact, Underwood didn't recall collecting much if any data. This made me wonder, how did Rosenhan get such specific figures for things like the total number of minutes psychiatrists spent on the ward, numbers so precise they came down to a decimal point?

Underwood led me to another of Rosenhan's former students, Harry Lando, now a public health psychologist at the University of Minnesota. Although his misdiagnosis with schizophrenia and 19-day hospitalisation match the account in Rosenhan's paper, little else does. Indeed, Lando wrote about his hospitalisation in an overlooked paper called "On Being Sane in Insane Places: A supplemental report" in 1976. The takeaway? Lando had a positive experience. He described the ward he was on as a healing, comforting environment, where the staff truly cared for the patients and they recovered.

In further handwritten notes he made while in hospital, Lando described touching moments of compassion and connection. However, none of this made it into the *Science* paper. Rosenhan instead dropped Lando from his study, making him only a footnote: "Data from a ninth pseudopatient are not incorporated in this report because, although his sanity went undetected, he falsified aspects of his personal history, including his marital status and parental relationships," Rosenhan wrote. Yet some details from Lando's 19-day hospitalisation, including his flirtation with a nurse, did make it into the paper.

What's more, an earlier draft of the paper, which I found in Rosenhan's files, featured nine pseudopatients and no footnote, leading me to believe that Lando hadn't yet been removed. Yet the draft listed the same number of pills taken, the same average length of stay and the same number of minutes psychiatrists spent on the ward as the published version. Not one number changed after he was taken out.

"Rosenhan was interested in diagnosis, and that's fine, but you've got to respect and accept the data," Lando told me. "Clearly, he had his idea, his hypothesis and he was going to confirm that hypothesis."

Adding it all up

What about the other participants? I spent years trying to find them and even hired a private investigator. Lando and Underwood only knew of each other, and even Rosenhan's long-time research assistant could only recall their two names. I could find no proof that the other pseudopatients existed.

COLLECTON CHRISTOPHEL/ALAMY STOCK PHOTO

One Flew Over the Cuckoo's Nest **brought mistrust of psychiatry to the silver screen**

> **"Despite years of hunting, I found no proof that the other pseudopatients ever existed"**

This isn't the first time a classic study of mental health has come under fire. In October, researchers at King's College London identified 26 papers written by world-renowned British psychologist Hans Eysenck, who died in 1997, as "unsafe". Among other things, Eysenck had claimed that personality had a bigger impact on someone's cancer risk than smoking.

Even the conclusions of Stanley Milgram's famous 1960s experiments on obedience to authority, in which participants subjected unseen people to increasingly painful shocks when told to do so by experimenters, have recently been cast into doubt, following the identification of serious methodological issues.

If Rosenhan had merely exaggerated the findings of a small, anecdotal study, I wouldn't be writing about him. But the effects of his paper can still be felt today. Within 10 years of its publication, the resident population in state and county psychiatric hospitals in the US had nearly halved, from 255,000 to 132,000. In the UK, there has been a similar drop in places for people in need of in-patient mental health treatment: today there are fewer than 20,000 beds available, compared with nearly 70,000 in the 1980s. The UK now has 1000 fewer beds than it needs to meet mental health demand, while the US is a staggering 95,000 beds short.

Many psychiatric hospitals were neglectful, even harmful places. Rosenhan raised valid points about their disturbing limitations, the view of psychiatric illness as less worthy of our sympathy and support than physical illness, the lack of validity of psychiatric labels and the role of priming in diagnosis. Yet by excluding and exaggerating data, he presented a sensationalised and oversimplified take on these complex issues. We are worse off because of it.

Today, many people with untreated mental health problems are living on the streets or are in prison. When Rosenhan conducted his study, 5 per cent of prisoners in the US met the criteria for serious mental illness; today, it is at least 20 per cent. According to a Harvard Medical School report, more than 100,000 people with serious mental health problems in the US are homeless.

People with mental illness are still often stigmatised and poorly treated. Most of the world contends with lack of beds, improper funding and shortages of mental health care professionals. By 2025, the US could be more than 15,000 psychiatrists short.

It is time to reassess the paths that took us here, and, in so doing, begin to set things right. Rosenhan may not have created these issues, but by only pretending to expose their true nature, he contributed to a culture that has caused harm to the people in greatest need. ∎

Susannah Cahalan is the author of *The Great Pretender*. Her previous book was *Brain on Fire*. She is based in New York

New Scientist

Know more. Live smarter.

Get *New Scientist*'s expert insights delivered straight to your email inbox with our free newsletters

Health Check

Look beyond the latest wellness crazes with our weekly newsletter of medical, diet and fitness news you can trust.

Brought to you in a carefully curated round-up by *New Scientist* health reporter Clare Wilson.

Sign up at **newscientist.com/healthcheck**

Clare Wilson

Fix the Planet

Overwhelmed by climate change and want to know how we can build a more sustainable future?

Get a weekly dose of climate optimism with *New Scientist* chief reporter Adam Vaughan.

Sign up at **newscientist.com/fix**

Adam Vaughan

The Daily

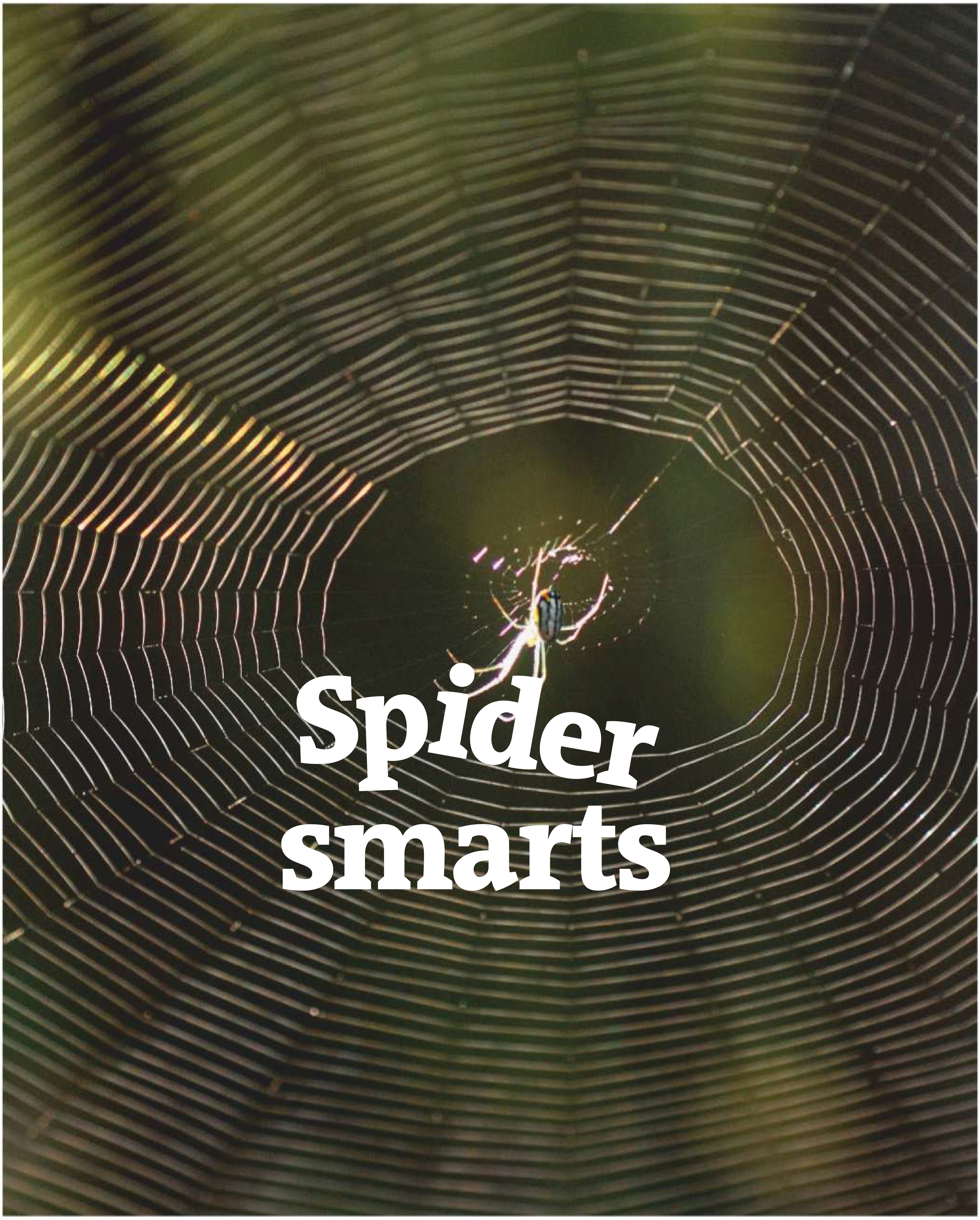
Each morning our daily newsletter brings you essential science and tech news from *New Scientist* and around the web.

Let our social media editor Sam Wong ensure you're never out of the loop.

Sign up at **newscientist.com/daily**

Sam Wong

Spider smarts



NHPA/PHOTOSHOT

Arachnid intelligence is challenging our ideas about brains and consciousness – and their minds may even stretch into their webs, finds **David Robson**

THERE is an alien intelligence living among us. These creatures possess an extraordinary kind of consciousness, including minds that extend beyond their bodies. Yet, thanks to our ignorance and arrogance, our immediate impulse is to kill them.

This is no fantasy. These alien minds really are lurking in the shadows of our houses and gardens: spiders. We have long assumed that, like many invertebrates, they are little more than automata, lacking an inner life. But we are now discovering that some arachnids possess hidden cognitive abilities rivalling those of mammals and birds, including foresight and planning, complex learning and even the capacity to be surprised. Stranger still, the delicate silk threads they spin out behind them, so easily swept up by a feather duster, help them to sense and remember their world. Indeed, spiders' silk is so important to their cognitive abilities that some scientists believe it should be considered part of their mind.

Now that we are starting to appreciate spiders' intellectual capabilities, we must surely change how we see one of the most ubiquitous, important and vilified groups of animals that has ever evolved. What's more, these incredible creatures could also challenge our understanding of our own intelligence and minds.

Spiders have deep evolutionary roots. The earliest fossil evidence of silk-producing arachnids dates from almost 400 million years ago, shortly after the first definitive evidence of insects. "Insects are the most successful lineage on Earth, but spiders pretty much follow them," says evolutionary biologist Miquel Arnedo at the University of Barcelona, Spain. Today, there are more than 48,000 known species, with every square metre of land home to around 130 individuals on average. That may terrify arachnophobes, but without them, agriculture would be impossible. "You couldn't have any crops – insects would eat them all," says Arnedo.

Spiders are defined by their eight legs and intricate spinnerets, which extrude silk. This is a protein made up of chains of amino acids, primarily glycine and alanine, that spiders extract and comb with their back legs to strengthen it. Some species can produce fibres with different chemical compositions depending on their particular need.

Spider silk – the envy of human engineers – is put to a huge range of uses, including building cocoons, windsurfing and as a rope for climbing and abseiling. Many spiders also use it for a sort of "flight" known as ballooning, in which a few threads, lifted by electrostatic forces in the atmosphere, carry them far and wide on nothing more than a light breeze. These species detect these forces with hairs on their legs, allowing them to decide when to put up their "sails". "They can feel the change in the air," says Erica Morley at the University of Bristol, UK, who made this discovery.

The sheer versatility of their silk helps explain the enormous evolutionary success of spiders, says Arnedo. But their intelligence will have been critical, too. The best evidence of spider smarts is found in the everyday activity of web building. Around a third of all species make orb webs, those beautifully geometrical deathtraps hanging in our houses and gardens. They hold more secrets than *Charlotte's Web*, because each is a record of the decisions taken during its construction.

Consider the basic question of where to build the web. Every species of orb web spider has a preferred size and shape of web to suit its body type and prey, but individuals tailor their constructions to fit into restricted spaces or around obstacles. This suggests that before building begins, some kind of planning takes place. That is particularly impressive when you consider that most spiders are almost completely blind. How do they do it?

One possibility, according to Thomas Hesselberg at the University of Oxford, is that they use their silk as a kind of plumb line to scout out a potential web site. When exploring, some spiders first cast a horizontal line between two surfaces and then traverse ›

"Webs are like instruments that spiders carefully 'tune' according to their experiences"

To construct an orb web, a spider must be capable of foresight and planning

it, descending and ascending at various points along the way. This could allow them to estimate the dimensions of the space. "Maybe they're somehow able to tell how much silk there is and how much time they spent exploring. That could potentially give an indication of how many times they passed through an area and how big it is," says Hesselberg.

The ability to form a mental representation of space has been documented in many mammals and birds, but is almost completely unheard of among invertebrates. Until now, the best evidence was in bees, which are thought to use mental maps to help them navigate – but even that has been contested.

Hesselberg's preliminary experiments suggest that the cognitive maps of orb web spiders aren't very detailed: they seem to include big obstacles but not little ones, for instance. Yet the ability to generate even a crude representation of their environment would help to explain other behaviours that appear to demand a certain level of foresight and planning. For instance, orb web spiders alter the size and structure of their webs according to the remaining silk reserves in their glands, ensuring that they don't run out midway. They are also sensitive to the weather: in low temperatures, they make simpler structures with bigger gaps between the spirals to avoid spending too much time exposed to the cold.

Cognitive sophistication is evident in the ways that spiders maintain and adapt a web after construction, too. They tweak the tension of silk strands in the areas most likely to trap unsuspecting insects, based on their previous catches. Increased tension boosts the transmission of vibrations from a struggling insect, allowing the waiting spider to respond more quickly. They also alter the dimensions of the web according to the size of prey found locally. They can even learn from near misses: if their prey hits the web but then escapes, spiders will lay down more sticky silk to ensure this doesn't happen in future. You could almost think of webs as instruments spiders carefully "tune" according to their experiences. "There is no doubt that they are much more flexible than we once believed," says Hesselberg.

Spiders are a varied group, of course, but species with very different lifestyles are proving equally smart. Take jumping spiders belonging to the genus *Portia*. Their preferred prey is other spiders, and these can be up to twice their own size. They catch them by stealthily roaming their environment, and have evolved astonishing eyesight to do this. "They hunt like tiny cats," says Fiona Cross at the University of Canterbury, New Zealand. This often involves premeditation and careful route planning, as her research reveals.

Mental maps

Working with her colleague Robert Jackson, Cross placed individual *Portia* on a tower in a water tank – like cats, they hate getting wet. From this viewpoint, they could see two floating pathways, one of which led to prey on another tower. Although the prey was out of sight once the spiders had descended, they invariably chose the correct route, suggesting they held a map in their working memory. In another experiment, Cross and Jackson provided two routes: both led to the prey, but one was shorter. Most spiders chose the quickest path. "For us, that suggests that *Portia* are making a plan of where to go," says Cross. In the wild, the spiders use this kind of premeditation to ambush dangerous prey from behind.

WV PICS/GETTY IMAGES

Jumping spiders have evolved astonishing eyesight to help catch prey

Social webs

We tend to think of spiders as solitary creatures, but around 20 species live in colonies of thousands where they share tasks such as foraging, web building and maintenance and care of the young. This lifestyle mostly occurs in the tropics and, in some species, may have evolved to cope with damage to webs caused by heavy rainfall. Protection against raiding ants is another possible benefit. Colonial spiders are also better equipped to catch the larger prey insects that are found in these regions.

Consider *Stegodyphus dumicola*, which lives in colonies of up to 2000 members in southwestern Africa. The colonies consist of two silk structures: the small and ball-like "retreat", where the spiders live, and the "capture web", which is large and flat and intended to catch prey. When the spiders sense the vibrations of an insect that has ventured into this trap, a few will come out of the retreat to inject it with venom. "When it stops moving, more spiders come in, start eating it and drag it back to the retreat," says Noa Pinter-Wollman at the University of California, Los Angeles.

Portia even seem capable of being surprised. In experiments similar to the previous one, Cross and Jackson changed the type of prey while it was out of sight of the spiders. This led them to pause – a sign of confusion, often used by psychologists to test what babies are thinking. *Portia* also pause for longer if they find more or fewer prey awaiting them at the end of the path, compared with what they had seen from their tower. That suggests these spiders have a basic number sense.

A dandy jumping spider (far right) lures its spider prey by pretending to be caught in its web

EMANUELE BIGGI/NATURE PICTURE LIBRARY

Despite *Portia*'s catlike stalking style, silk is still essential to their survival, and they often employ it when hunting. They sometimes build a web as a vantage point from which to abseil onto prey, or as a means of catching insects to use as bait for tasty spiders. *Portia* also invade other spiders' webs and pluck the silk to mimic a trapped insect, drawing occupants from their hiding places so they can pounce and kill them. They seem to learn the correct vibrations through trial and error.

> **"Given spiders' smarts, might we even consider them to be conscious?"**

Such findings, combined with new evidence of spider sociability (see "Social webs", left), indicate advanced cognition across many spider species. Yet the brains of these creatures are often minute: most orb weavers, for instance, weigh between 50 and 80 milligrams, with some less than 1 milligram, and their brains are just a fraction of that. Spiders' ancient origins also raise some profound philosophical questions about the evolution of the brain. Previously, we have tended to look for intelligence in our closer relatives, but broadening the web to animals like spiders has proved profitable. "The success of this line of research shows that we should be careful not to restrict our research questions or study species," says Caroline Strang at the University of Texas at Austin, who investigates insect cognition.

These findings have even caused us to reconsider the definition of the animal "mind". Take the concept of extended cognition, an idea that has been of particular excitement to psychologists of late. Philosophers coined this term to describe the way our tools become incorporated in our thinking. We turn to a notebook or smartphone, for instance, as an external memory source that can be accessed at will. In this view of cognition, our minds extend beyond our brains to all the objects that contribute to our perception, memory and reasoning. Hilton Japyassú at the Federal University of Bahia in Brazil and Kevin Laland at the University of St Andrews, UK, have made a strong case that a spider's use of silk qualifies as a natural example of extended cognition. After all, a spider's past experiences can determine the structure of its web, which, in turn, alters what it senses in its environment, directly influencing its future decisions. As a result, part of a spider's memory and decision-making is outsourced beyond its body.

Much as tool use has aided human success, spiders might have evolved extended cognition to help them survive and thrive in varied environments. "Spiders have extra selective pressure for evolving extended cognition because of their relatively tiny brains and their high cognitive requirements as generalist predators," says Japyassú.

Given the new discoveries, might we even attribute consciousness to spiders? Most researchers see consciousness as a spectrum, ranging from a basic mental representation of the surrounding environment and the capacity to shift attention between elements, to imagination, advanced self-awareness and metacognition, the capacity to reflect on your own judgements. Most invertebrates are considered incapable of even the most basic level of conscious experience, responding to situations automatically instead. But spiders' mental representation of space and their capacity for foresight and planning appear to reflect more complex inner experiences. "We've seen that *Portia* are able to 'think' about what they are doing before actually doing it," says Cross.

This is exciting because it means that spiders could provide valuable information about which neural structures are necessary for conscious experience, as well as how these evolved. In a vertebrate, the midbrain gathers sensory information and bodily signals, then integrates these to create a mental simulation of the world and the creature's place in it. This, in turn, directs its attention and movement according to its needs, creating an "experiential consciousness" on which to build other types of awareness, such as self-reflection. "It basically underpins everything," says Andrew Barron at Macquarie University, Australia.

Invertebrate brains take a different form, but a structure called the central complex shows the same connectivity in insects, argues Barron. In spiders, a region known as the arcuate body may have the same purpose. Detailed studies of spider brains have been low on neuroscientists' lists of priorities. However, if further evidence supports the idea that these regions create an inner representation of the world, this could help us pinpoint a date for the emergence of conscious experiences – potentially more than half a billion years ago, when the Cambrian explosion gave rise to almost all the animal groups around today.

In the meantime, a greater appreciation of spider smarts might give us all pause for thought the next time we are confronted with eight-legged squatters hiding in our hallways. Written on their silken webs, we may one day find clues to the origins of thought itself. ▮

David Robson is the author of *The Intelligence Trap: Revolutionise your thinking and make wiser decisions*

Making history

The most widely used encyclopedia on the planet has huge gaps when it comes to influential women or people of colour in science. Physicist Jess Wade is trying to fill them, she tells **Joshua Howgego**

WHEN Jess Wade isn't working in the physics laboratories of Imperial College London, she is fighting to make science more accessible for all. Her flagship project is to create and edit articles on Wikipedia, humanity's largest ever encyclopedia, to ensure that the scientific contributions made by women and other under-represented communities aren't lost to posterity. It is thanks to her that the website has pages on Magdalena Skipper, the first woman to serve as editor-in-chief of the journal *Nature*, Jo Dunkley, the astrophysicist and science communicator at Princeton University, and almost 900 other pioneering women in science.

Anybody with an internet connection can edit Wikipedia, but most of its tens of thousands of editors remain in the shadows. Wade has made headlines, however, winning the Wikimedia Foundation's 2019 award for UK Wikimedian of the year. But not all the attention has been positive. Late last year, a string of her articles were flagged for deletion by fellow editors, ostensibly because their subjects were insufficiently noteworthy for a global audience. She publicly called those editors out for systematic bias and the controversy made it into the UK press, highlighting the shadowy power plays that dictate what information ends up on Wikipedia.

We spoke to her about what drove her to undertake this project and why it sometimes isn't so well received.

Joshua Howgego: What makes Wikipedia worth your time?

Jess Wade: Wikipedia is visited millions of times a day – that's just the English version – by people all over the world, in all walks of life, which makes it a super, super important platform. But only about 18 per cent of the English-language biographies are about women and, while it's harder to get data on other under-represented groups, there is no doubt that scientists with disabilities and from the LGBTQ community, for example, are less likely to have a Wikipedia page. So since the beginning of 2018, I've been trying to improve the representation of women scientists and people of colour on it, and particularly people from the global south.

Have you faced any challenges getting these profiles on Wikipedia?

Wikipedia has strict eligibility criteria for notability. Fair enough – not every single person you meet should be on there. The problem is that the criteria are written in a way that ensures white male academics are more prevalent on the site than other scientists: achievements like holding named chairs at an institution, having contributed widely to scientific literature and holding prestigious awards and fellowships. Things we know are biased towards white men from Western countries. The hardest one is finding some independent, reputable source that has already written about these scientists. As a result, my biographies sometimes get flagged as being not notable enough for inclusion. One weekend in late 2019 I tweeted about this issue, and it got a lot of attention because people thought that it was Wikipedia that was responsible rather than other editors.

THOMAS ANGUS/IMPERIAL COLLEGE LONDON

Why do you think those editors flag your pages in this way?

It really surprises me that this happens. Wikipedia really is a global project, and we're all working together on this free knowledge. Why then, when some other editor reads a page that they think could do with an extra citation, do they not look for one themselves? I think there are some weird power dynamics going on, with a few individual editors at the top of Wikipedia's hierarchy who think that they can control what information is valued by the site.

What was it that got you started as a campaigner outside your day job?

It was when I read Angela Saini's book *Inferior*. I think Angela is the most important writer and broadcaster that we have in the UK right now. *Inferior* looks at the way women have been misinterpreted in and misreported by science. When I read that book, it completely transformed the way I think about inequality.

THOMAS ANGUS/IMPERIAL COLLEGE LONDON

Have you had to overcome any obstacles yourself?
One episode in particular really frustrated me. I had just been invited to speak at a nanomaterials conference in Paris. I looked at the website and it was sadly typical: a wall of 32 photographs of white men. Instantly when you see that kind of thing, it makes you think: they didn't invite me for my research, but because someone had criticised their lack of diversity. I wrote back and raised some concerns, and, to cut a long story short, I ended up recruiting a group of fantastic women to come and speak at this meeting. But then we were sidelined into a parallel session for about 12 people called "Women in nanomaterials". It was just us women talking to each other about our work. I have never felt so patronised and humiliated in my life.

> **"There are some weird power dynamics on Wikipedia"**

Tell us more about your work on nanomaterials.
I'm trying to make new materials for use in TV screens and mobile phone displays. I work in particular with semiconductors that have chiral properties, which means that their structures are non-superimposable mirror images, like your left and right hand. We can get these molecules to absorb and emit light in far more sophisticated ways than present-day materials so that when you put them in your TV or mobile phone, the screen is much brighter and uses much less power.

Does chirality matter beyond the lab bench?
Lots of things are chiral, including snail shells, screws and fusilli pasta. Actually, it turns out that about 95 per cent of fusilli is a right-handed helix. But the most efficient way to pack the pieces of pasta together would be if we had equal quantities of the left and right-handed sort. Because we disproportionately make right-handed pasta, the packets have to be about 10 per cent bigger than needed.

What do you think we should do to encourage more girls to study physics?
We've got to a state in the UK where people are doing an awful lot of outreach at the school level. But for physics, the gender balance of both A level and undergraduate courses hasn't shifted in 50 years. We still have this misconception that if scientists go and stand in front of 40 kids for a lunchtime, we'll inspire them all to study A level physics. That's naive. Instead, we should try to think about using evidence a bit more, using things that have worked. For example, if a scientist worked with one schoolteacher for the whole of their PhD, this would probably result in more pupils having chosen to study physics than if they went to a different school every week.

If you could have a long conversation with any of the people you've written about, who would it be?
A mathematician called Gladys West. Hers was one of the first Wikipedia pages I made. She was born in 1930 in Virginia, and studied maths in a completely different environment to today. She went on to work for the US government and did early computing that was the basis for GPS technology. Since the Wikipedia page went up, she's been in the BBC's 100 Women list, an annual line-up of influential and inspirational women chosen from around the world. She's been inducted into the US Air Force Space and Missile Pioneers Hall of Fame, and she finished her PhD by distance learning in 2018. This woman is approaching 90 and is still a rock star. ■

Joshua Howgego is the education editor at *New Scientist*

New Scientist Jobs

Putting brilliant minds to work

Sign up, create your own job alerts and discover the very best opportunities in STEM at

newscientistjobs.com

Recruitment advertising
Tel **+44 (0)20 7611 1204**
Email **nssales@newscientist.com**

@science_jobs #sciencejobs

THE UNIVERSITY OF TENNESSEE HEALTH SCIENCE CENTER

POSTDOCTORAL POSITION - Vascular smooth muscle and endothelial cell ion channels

NIH-funded postdoctoral position immediately available to study physiological functions and pathological alterations in arterial smooth muscle and endothelial cell ion channels. Projects include studying blood pressure regulation by ion channels and regulation of trafficking, signaling and functions of TRP, BK_{ca}, K v and voltage-dependent Ca^{2+} channels, similar to studies we have recently published (Kidd et al. Science Signaling 2015, Leo et al. Science Signaling 2017, Bulley et al. eLife 2018, Hasan et al. PNAS, 2019). Techniques in the laboratory include, RT-PCR, Western blotting, biotinylation, immunofluorescence, FRET, patch-clamp electrophysiology, calcium imaging, pressurized artery myography, blood pressure telemetry and conditional knockout mouse models. Experience with molecular biology, ion channel biochemistry, patch clamp electrophysiology, and cardiovascular physiology preferred. Required qualifications include a PhD or MD in Physiology or a related field.

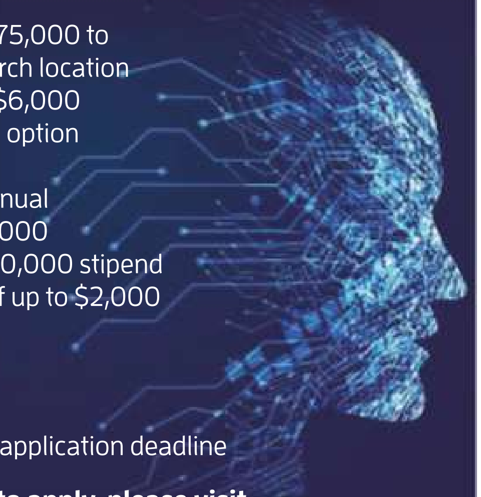
Send curriculum vitae and names and addresses of three references to Dr. Jonathan H. Jaggar, Maury Bronstein Endowed Professor of Physiology, Department of Physiology, University of Tennessee Health Science Center, 894 Union Avenue, Memphis, TN 38163, USA. **jjaggar@uthsc.edu**. https://www.uthsc.edu/physiology/faculty /jjaggar. php

The University of Tennessee is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.

Intelligence Community Postdoctoral Research Program Fellowship Program

The Intelligence Community (IC) Postdoctoral Research Fellowship Program offers scientists and engineers from a wide variety of disciplines unique opportunities to conduct research in a wide range of topics relevant to the Intelligence Community. The research is conducted by the Postdocs, while working in partnership with a Research Advisor and collaborating with an advisor from the Intelligence Community.

In partnership with the Research Advisor, the Postdoc composes and submits a technical proposal that responds to a research opportunity identified at:
https://orise.orau.gov/icpostdoc/current-opportunities.html



Award Details:

- Annual stipends range from $75,000 to $79,000, depending on research location
- Annual travel budget of up to $6,000
- Appointments for 2 years, and option to extend for a third year
- Host institutions receive an annual laboratory budget of up to $5,000
- Research Advisors receive a $10,000 stipend and an annual travel budget of up to $2,000

Postdoc Eligibility:

U. S. citizenship required
Ph.D. received within 5 years of the application deadline

To learn more and to apply, please visit
https://orise.orau.gov/icpostdoc/

Applications Accepted January 6 - February 28, 2020

REGISTER TODAY

Research scientists and employers,

JOIN US AT AACR'S ANNUAL

CANCER AND BIOMEDICAL RESEARCH CAREER FAIR

April 25, 2020 | AACR Annual Meeting 2020 | San Diego, CA

FOR MORE INFORMATION AND TO SIGN UP

Visit **CancerCareers.org**, call **215-440-9300**,
or email **CareerFair@aacr.org**.

CancerCareers.org

Powered by AACR American Association for Cancer Research®

Scientists at all levels:
Upload your CV/resume today

Employers:
Post Positions

New Scientist
Discovery Tours

ITALY

Science of the Renaissance

Encounter the greatest scientific minds and discoveries on a cultural adventure across the pre-eminent cities of Renaissance science – Florence and Bologna

Galileo Galilei and Leonardo da Vinci are just the start. This awe-inspiring tour will take in illuminating astronomical, anatomical, architectural, medical and mathematical perspectives as it revels in the wondrous collections, buildings and churches of the Renaissance.

While enjoying the beautiful cities of Florence and Bologna, you will stay in 4-star hotels and tours will be led by art and architecture expert Andrew Spira and accompanied by scientific historian Professor David Wootton.

A life affirming experience that includes 4-star hotels, evening seminars, flights from Heathrow (which can be changed to another airport) and entrance to all sites and attractions.

To book call +44 207 251 0045
(UK opening hours Mon to Fri 9am to 5pm GMT)
Or email tours@traveleditions.co.uk

Departing:
3 March 2020
3 November 2020
7 days for £1,825 (approx $2,319)

In partnership with Travel Editions

newscientist.com/tours

The back pages

Puzzles
A quick crossword, a beetle problem and the quick quiz p52

Feedback
Joy of the rovers and a puzzle puzzle: the week in weird p53

Twisteddoodles for *New Scientist*
A cartoonist's take on the world p53

***Almost* the last word**
How can you get flu after vaccination? Readers explain p54

The Q&A
Psychologist **Suzi Gage** on saying why to drugs p56

Science of cooking **Week 6**

Chocolate magic

Understanding the structure of chocolate will give you mastery over it, says **Sam Wong**

Sam Wong is social media editor at *New Scientist*. Follow him @samwong1

What you need

White chocolate
Dark chocolate
Thermometer
Hazelnuts
Coffee beans
Sea salt

For next week

Kombu (dried kelp)
Katsuobushi (tuna flakes)
Miso paste
Silken tofu
Spring onion

Next in the series

1 Caramelising onions
2 Making cheese
3 Science of crispiness
4 Tofu and Sichuan pepper
5 Gravlax and curing
6 Tempering chocolate
7 Umami and flavour
  How to maximise that rich, savoury taste
8 Perfect pancakes
9 Kimchi and fermentation
10 Sourdough bread

JAMES WINSPEAR

Science of cooking online

All projects are posted at newscientist.com/cooking Email: cooking@newscientist.com

IF THERE is someone you would like to impress on Valentine's day, this swirly chocolate slab could be just the thing. Simply melting and mixing the chocolates won't do, however. To make glossy, smooth chocolate with a pleasing snap, you need a little knowledge of its chemical structure.

The chocolate we know is a far cry from the astringent cocoa bean from which it originates. The cacao tree has been cultivated in Central America for more than 3000 years. Archaeologists have found chemical traces of cacao on pottery dating to 1600-1800 BC.

Cocoa beans grow in large pods packed with fibrous, sugary pulp. To make chocolate, the beans are first fermented in the pulp. Bitter phenolic compounds react and form less bitter complexes, while enzymes in the beans break down sugars and proteins into compounds that react more easily in the next step: roasting. Maillard reactions then produce the full, complex flavour of chocolate.

The roasted beans are ground, breaking the cells into particles suspended in fat, known as cocoa butter. The mixture can be turned into chocolate by adding ingredients such as sugar and milk solids. It is then mechanically worked in a process called conching, before being cooled into solid bars.

The texture of chocolate is determined by the crystal structure of the fat molecules. The glossy surface and pleasing snap of a good bar of chocolate arise when the fat molecules align in a dense network of compact crystals. If chocolate melts and resolidifies in an uncontrolled way, the molecules form loose, irregular crystals that result in soft, mottled, crumbly chocolate.

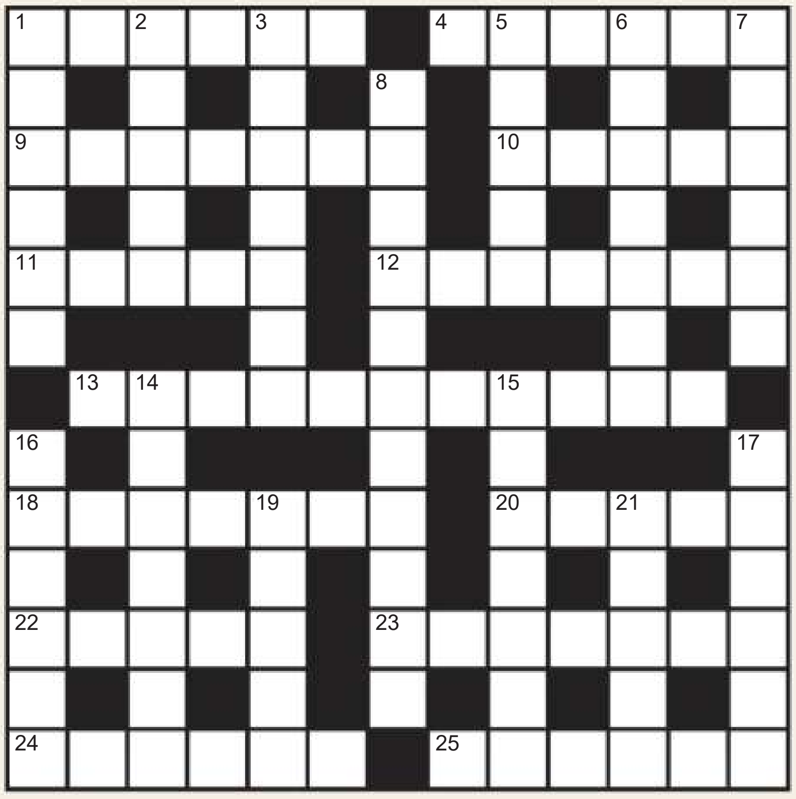
Tempering is a way of creating the right crystalline structure. You will need a thermometer because the key is to hold the temperature at 31 to 32°C, which is below the melting point of the right crystals and above the melting point of the wrong crystals.

Break or chop 300 grams of dark chocolate into small pieces and hold a few in reserve. Melt the rest in a bowl over a pan of hot but not boiling water. Once it is all melted, remove from the heat and stir in the reserved chocolate, which will seed the melted chocolate with the right kind of crystals. Keep stirring until the temperature falls to 31 to 32°C. Hold it at this temperature until you are ready to use it.

Do the same with 300 grams of white chocolate in a separate bowl, but keep it at 27 to 28°C.

Line a tray with baking paper. Pour in the dark chocolate, then pour the white over the top. Use a chopstick to make patterns and ensure there are no holes in the slab. Drop in some hazelnuts and coffee beans – or anything else you like – along with flakes of sea salt. Let it cool at room temperature to allow the crystalline structure to develop fully. Wrap up the whole slab as a gift, or break it into pieces. ▮

Cryptic crossword #24 *Set by Wingding*



ACROSS

1/4/16 This year, plan to get good eyesight (6,6,6)

4 See 1 Across

9 Extreme weather damaged a pet, cutting off its tail (7)

10 Slimy creatures have information about Tory leader (5)

11 Space explorers initially lost in a cavity (5)

12 Come before 2 April and go back (7)

13 Disappointing about climate activist taking time to be around loved one (11)

18 Back in here, get nine or 10, perhaps (7)

20/23 Beautiful woman getting right into spiritual leader and astronaut (5,7)

22 Emotional, I speed (5)

23 See 20 Across

24 Two ants at sea, swimming (6)

25 Drug user's phlogiston eradicated partially (6)

DOWN

1 Tweets annoy intermittently, causing muscle spasm (6)

2 Makes headless carnivore stand on poles (5)

3 Short sea bird eating marsh bird in caravan (7)

5 Grimace, seeing carbon in drink (5)

6 See 19 Down

7 Spooner's predicament: money makes people unwilling to say no (3-3)

8 Make digital customer pie mixture (11)

14 Distillation of additional cat extremities (7)

15 Goya the artist hiding under the surface (2,5)

16 See 1 Across

17 More stupid and mad to lose second resistor (6)

19/6 Developed renewed angle on plan to tackle climate change (5,3,4)

21 Gents toilet heard above, in space (5)

Answers and the next quick crossword next week.

Quick quiz #37

1 Vitamins are organic micronutrients essential to the functioning of an organism's metabolism. How many are humans generally considered to need?

2 Which vitamin, also known as cobalamin, is essential to the functioning of the nervous system and generally only found in animal-derived foods?

3 The synthesis of cholecalciferol in the skin on exposure to UVB radiation is one way humans acquire which vitamin?

4 Which disease, with effects on the cardiovascular and nervous systems, is associated with a deficiency of vitamin B1, or thiamine?

5 A spinach, red pepper, grapefruit and parsley smoothie would hugely boost your intake of which vitamin?

Answers below

Quick crossword #50
Answers

ACROSS 1 Eureka, **4** Itchweed, **10** Cyberpunk, **11** Xylem, **12** Dodo, **13** Meningitis, **14** Neutron, **16** Etna, **19** Mons, **21** Allheal, **24** Metropolis, **25** Germ, **27** Sci-fi, **28** Parkinson, **29** Skeleton, **30** Skidoo

DOWN 1 Encoding, **2** Rubidium, **3** Kirk, **5** Tektite, **6** Hexagonal, **7** Eolith, **8** Demist, **9** Tune in, **15** Rhodolite, **17** Reversed, **18** Flamingo, **20** Scorpio, **21** Aviary, **22** Emesis, **23** Strike, **26** Dick

Quick quiz #37
Answers

1 Thirteen: vitamins A, B1, B2, B3, B5, B6, B7, B9, B12, C, D, E and K

2 Vitamin B12

3 Vitamin D

4 Beriberi

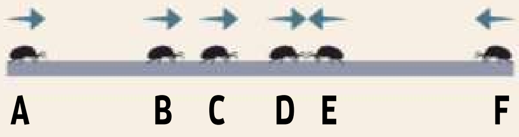
5 Vitamin C. By mass, parsley has almost three times as much vitamin C as fresh orange juice

Puzzle *set by Rob Eastaway*

#45 Beetles on a clothes line

Peg beetles are a rare species with rather odd behaviour. As any peg beetle expert will know, these beetles always walk at 1 metre per minute, and when two beetles meet, they immediately reverse direction.

Six peg beetles are on a 2-metre-long clothes line, some walking left to right



and others right to left (as the diagram shows). As we join the action, beetle A is at the left-hand end of the line and walking towards the right, while beetle F is at the right-hand end, walking left.

When a beetle reaches the end of the clothes line, it drops off onto the ground.

Which two beetles will be the last to drop off the clothes line, and how long will it be before that happens?

Answer next week

#44 Elevator pitch
Solution

In a lift accelerating upwards, neither the helium balloon nor the ice cube move at all. The spider does move down, however.

Anything floating, as Archimedes postulated, is subject to an upwards buoyancy force equal to the weight of the displaced fluid. Gravity, as Einstein explained, cannot be distinguished from acceleration so everything feels heavier in the accelerating lift, including the water, ice cube, helium and air. The spider also feels heavier and so the silk it hangs from has to stretch, by Hooke's law.

Get in touch

Email us at

crossword@newscientist.com

puzzles@newscientist.com

Beef stock

Prediction is difficult – especially about the future, as Niels Bohr might have said (but apparently it is just as difficult to predict who invented well-used aphorisms in the past). As such, we can safely assume that anyone who earns lots of money by investing in stocks that go up in value must be very clever indeed. Or can we? A neat experiment performed on a Norwegian television show and related by the *Financial Times* illustrates flaws in this line of reasoning.

The programme challenged two stockbrokers to an investing contest. Their competition? An astrologist, two beauty bloggers and a herd of cows. The cows chose their stocks by placing deposits (of the biological variety) on a grid where each square was assigned to a different company.

After three months, the stockbrokers achieved a return of 7.28 per cent, marginally ahead of the cows, which managed 7.26 per cent. The winners, however, were the beauty bloggers, whose portfolio went up by more than 10 per cent.

The presenters then sprang a surprise, revealing that they had their own portfolio, which gained almost 24 per cent. However, they had actually chosen 20 different combinations, and ditched the worst ones. Fund managers can use a similar strategy to inflate their performance, shutting down funds that do badly in their early years so that the remainder show more impressive results.

What's an investor to do? Well, bovine-assisted stock selection appears to be as good a strategy as any, but only in a bull market. In a bear market, head to the woods.

Religious text

There are some questions that science can't answer. But there are others that only science can, 74 of which are answered in the *New Scientist* book, *Why Do Boys Have Nipples? And 73 other weird questions that only science can answer.*

Not the pithiest of titles, we admit, but at least it has the virtue of making it very plain what sort of book it is. Or so we thought, until we discovered that e-commerce behemoth Amazon had placed the book in the "religion" category.

How did it end up there? Was it the product of random chance, or intelligent design? This, unfortunately, is not one of those questions science can help with.

A puzzle puzzle

Our attention was drawn this week to regular reader and puzzle solver extraordinaire Jim Randall. Jim has set himself a goal of solving *New Scientist*'s entire back catalogue of puzzles, and has been recording progress on his website (enigmaticcode.wordpress.com).

Not only has he solved all of the puzzles in our current series, but he has also tackled many of our much-loved Enigma puzzles, which ran from 1979 to 2013. Helping him in this endeavour is a mastery of the Python programming language, which has allowed him to code his way to easy and elegant solutions.

***Feedback* is inherently suspicious of this level of skill, and has begun to wonder whether we might not in fact be dealing with a hyperintelligent neural network masquerading as a man named Jim.**

To get to the bottom of this, we might have to ask the *New Scientist* puzzle editor to set a riddle no machine would ever be able to solve. Any suggestions for what such a fiendish conundrum could look like would be gratefully received.

Circular argument

Solecism of the week award goes to Circle Economy, a non-profit organisation. In a recent report highlighting the dire state of global recycling infrastructure, it lamented the low percentage of goods which could be said to be part of a truly circular economy.

A worthy message, we are sure you would agree. It was just a shame that they chose to phrase it with the words: "The world is now only 8.6 per cent circular." Still, at least it cheered up some flat-Earthers.

Joy of the rovers

If we are ever visited by travellers from another world, we will learn much about them by the name of the ship they arrive in. If it is called Vision or Clarity, we can conclude that their civilisation, like ours, is ruled by branding consultants.

Nomenclature is a tricky business, especially for people more versed in science than art, as the astronomers behind the Very Large Telescope will attest. Inviting suggestions from the public can be helpful, but these days administrators are careful to keep a tight grip on the process, fearful of allowing the likes of Boaty McBoatface a route to victory.

To name its next Mars rover, NASA is holding a competition open to students from kindergarten through to 12th grade. Nine finalists were chosen from the submissions, and a public vote will be only one factor in deciding the winner.

The final nine include a great variety of highly imaginative names, if your idea of imaginative names is restricted to abstract nouns representing admirable personality traits. The list looks like a flip chart you might find in a conference room after a group of middle managers have been asked to list their company's brand values at an office away day.

From *Feedback*'s viewpoint, Ingenuity, Fortitude and Courage serve only to highlight what is missing from the choices on offer. You might call it a huge missed Opportunity. ■

Twisteddoodles *for New Scientist*

My ♥ for you is like good Science requiring Proof & Peer approval.
DO YOU WORK FOR NASA? BECAUSE YOU ARE OUT OF THIS WORLD
You're like SCIENCE Because you make EVERYTHING make sense
YOU'RE LIKE MY PHONE I could lie in bed awake all night just looking at you
@twisteddoodles

Got a story for Feedback?

Send it to New Scientist, 25 Bedford Street, London WC2E 9ES or you can email us at feedback@newscientist.com

Going viral

I had my flu vaccination, then promptly came down with a really bad case of flu three weeks later. How can that happen?

Nikki Walters,
Wakefield, West Yorkshire, UK
The first possibility is that perhaps it wasn't the flu. The vaccine only protects against the influenza virus but there is a whole menu of possibilities when it comes to diseases with flu-like symptoms.

Secondly, even if it was influenza that you had, there is a chance you caught a strain that wasn't covered by the vaccine. There are many different strains of influenza virus, and several can be circulating at once.

Jane Monroe
Arcata, California, US
Every year, immunologists must predict which strain, or strains, of flu virus will dominate during flu season. This is so the correct vaccine can be produced. Making this prediction is difficult, so sometimes the vaccine doesn't match the virus strain that is circulating most widely.

There are multiple strains of influenza virus circulating during flu season, and you may have been infected by one of those that wasn't included in the vaccine.

Lewis O'Shaughnessy
London, UK
More than 200 different viruses cause flu-like symptoms. Each has different antigens – parts of the virus that would be targeted by antibodies – and so requires a different vaccine. On top of this, influenza viruses are able to mutate rapidly, so vaccines are only effective for a few years.

Rob Colebrook
Clee Hill, Shropshire, UK
Firstly, and most importantly, a flu vaccine can't give you influenza. Secondly, unless you had a blood test or nasal swab to prove it, it is unlikely that you actually had influenza. When I practised as a GP, the vast majority of patients who thought they had influenza were more likely to have been infected with a parainfluenza virus – which is like influenza – or a rhinovirus or adenovirus, which both cause a cold.

Thirdly, it takes between two and four weeks after having the vaccine for antibodies to influenza to develop, so it is possible to get flu before you have full protection.

Michael Allen
Ottawa, Ontario, Canada
A surveillance system developed by the World Health Organization attempts to identify the strains of flu circulating around the world from swabs of the nose and throat of patients with flu symptoms. The WHO then recommends the strains to be included in the vaccine for the upcoming season.

There isn't always a good match between the strains in the vaccine and those that actually cause influenza that year. In addition, some countries, including Australia, choose to follow their own recommendations rather than those of the WHO.

A 2018 review by the Cochrane Collaboration found that flu vaccine cuts the risk of healthy adults getting influenza from 2.3 per cent without vaccination to 0.9 per cent with it.

John Philpott-Howard
London, UK
Vaccines are never 100 per cent effective in all people, although two doses of measles vaccine (as MMR) come close, giving more than 99 per cent protection.

Also, immunisation can result in a suboptimal immune response, for a variety of reasons: poor vaccine administration technique, for example, or because of other health problems affecting your immune system at the time.

It is important to note that even if you get infected by the influenza strain that is in the vaccine that year, it is likely that you will have a modified illness. Although it may feel like a bad case, the vaccine may have partially protected you from even more severe disease.

Tim Lewis
Consultant chest physician, Landshipping, Pembrokeshire, UK
It is possible to be infected with influenza virus when attending a crowded surgery for the injection and fall ill before immunity has had time to develop.

Anna Butcher
Brookton, Western Australia
My GP advises vaccination some months ahead of the flu season so that I have maximum immunity when it arrives.

David Critchard
Exeter, Devon, UK
Like me, my son is allergic to vaccines cultured in eggs. I decline to be vaccinated, but he is a surgeon, so is vaccinated as soon as the latest one becomes available. He is then ill, sometimes needing intensive therapy unit treatment for up to a month.

Two years ago, he was vaccinated and had the allergic reaction. Some time afterwards, a patient was flown in, having been shot in a remote region of Pakistan, where people often go unvaccinated. He was patched up, but my son and his colleagues went down with a dangerous flu. It hadn't been included in that year's vaccine. My son infected his sister. The virus killed the baby she was carrying and almost killed her.

Even if the effects of vaccination can be unpleasant, the consequences from the lack of it can be much worse.

Apart from microorganisms, does anything eat foxes?

STEPHEN DALTON/NATUREPL.COM

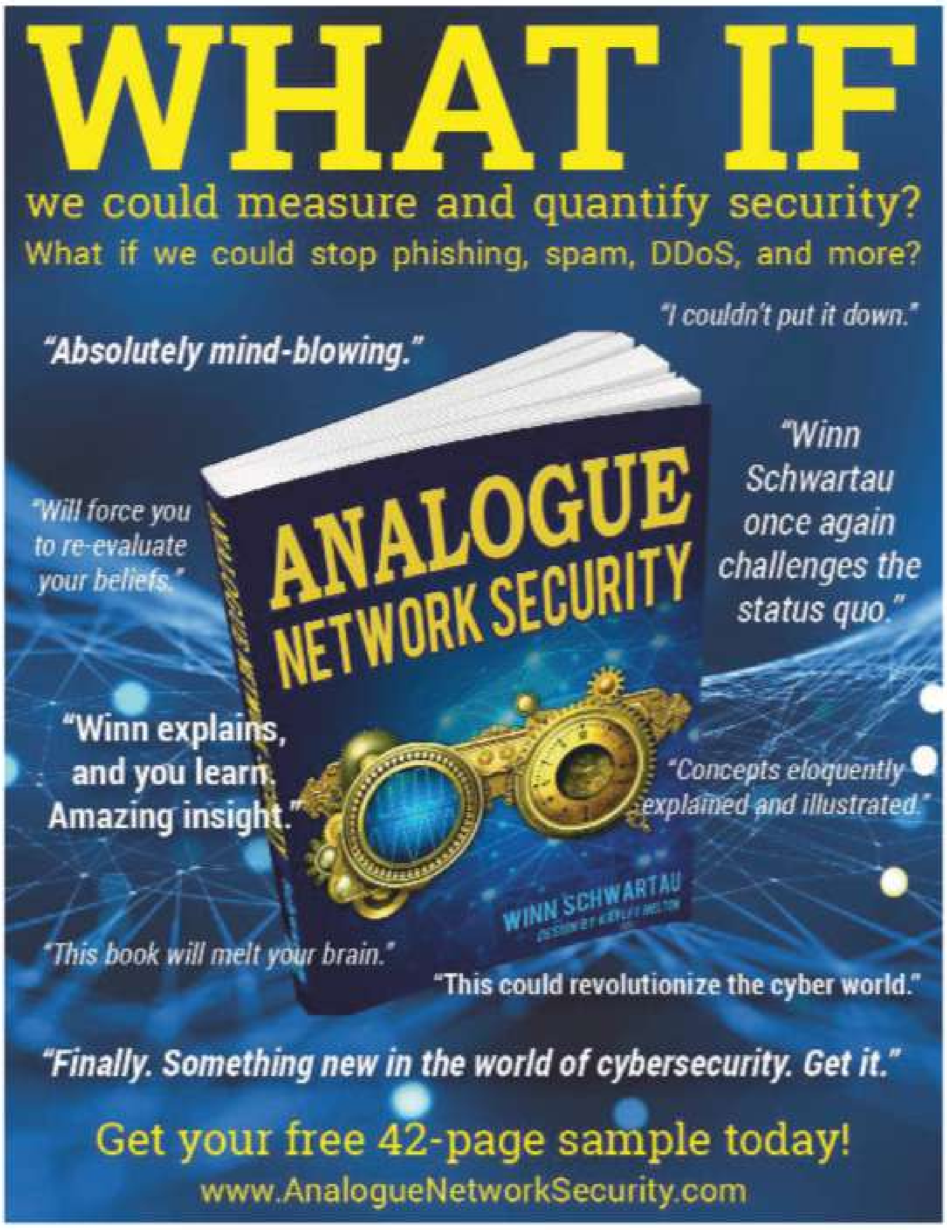
This week's new questions

Awful eaters **Foxes have the most repulsive smell, alive or dead. We often see dead foxes on our farm and they just decompose in situ. So, does anything eat foxes?** ***Anna Butcher,*** *Brookton, Western Australia*

The nose knows **Rust doesn't appear to release molecules into the air? So how does it have a smell?** ***Hugh Cartwright,*** *Victoria, British Columbia, Canada*

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

redmolotov.com
0121 559 2685. Ethically sourced. Up to 5XL
Free UK postage on orders over £50
CHEMISTRY
LIKE COOKING, ONLY WITH EXPLOSIONS
PROUD TO BE A
Girly Swot
THERE IS NO PLANET B
NO AMOUNT OF EVIDENCE WILL EVER PERSUADE AN IDIOT
Great Wave (Ocean Plastics)
PEOPLE'S REPUBLIC OF PANGAEA
LIFE
THE UNIVERSE
42
EVERYTHING
EVERY DISASTER MOVIE STARTS WITH SOMEONE IGNORING A SCIENTIST
We Do Mugs Too!
EARTH IS ROUND
VACCINES WORK
WE'VE BEEN TO THE MOON
CHEMTRAILS DON'T EXIST
CLIMATE CHANGE IS REAL
DINOSAURS HAD FEATHERS
EVOLUTION IS A FACT


WHAT IF
we could measure and quantify security?
What if we could stop phishing, spam, DDoS, and more?
"Absolutely mind-blowing."
"I couldn't put it down."
"Will force you to re-evaluate your beliefs."
ANALOGUE NETWORK SECURITY
WINN SCHWARTAU
"Winn Schwartau once again challenges the status quo."
"Winn explains, and you learn. Amazing insight."
"Concepts eloquently explained and illustrated."
"This book will melt your brain."
"This could revolutionize the cyber world."
"Finally. Something new in the world of cybersecurity. Get it."
Get your free 42-page sample today!
www.AnalogueNetworkSecurity.com

New Scientist
Discovery Tours

Kepler's Prague: Music of the spheres

Departing: 14 April 2020 and 14 September 2020

6 days for £1,968 (approx $2,499)

This unique tour allows you to experience how Johannes Kepler developed his theories around "music universalis" and planetary motion in stunning Prague, the city of a hundred spires.

In terms of achievement and courage, Kepler is considered greater than Galileo. The 12 years he spent in Prague during the 17th century were the most productive of his life. But Europe was still gripped by superstition, which led to conflict between politics, religion and science. That made it a dangerous time for astronomers such as Kepler.

Accompanied by author, broadcaster and Royal Astronomical Society fellow Jane Green, guests will discover what remains of the legacy of Kepler and his mentor Tycho Brahe, and explore the medieval centre of Prague plus its surrounding regions.

To book call +44 207 593 2284

(UK opening hours Mon to Fri 9am-6pm GMT Sat 9am-4pm GMT)

Or email culturaltours@kirkerholidays.com

newscientist.com/tours

There is a lot of misinformation and ignorance about drugs, says psychologist **Suzi Gage**. She is out to change that with a podcast and book called *Say Why to Drugs*

Explain your work in one easy paragraph.

I explore the relationship between recreational drug use and mental health. It is surprisingly hard to unpick what might cause what. We see more drug use in people with poor mental health, but is this because drugs increase the risk, or because people with poor mental health are drawn to use drugs, or that other factors affect the likelihood of both?

How did you end up working in this field?

When I was studying psychology at University College London, I took a module called "Drugs and the Mind". The practical involved us taking either alcohol or nitrous oxide and doing a number of cognitive and fine motor tasks. I was fascinated by the course, and realised, maybe for the first time, that different drugs can have very different effects.

As a child, what did you want to be when you grew up?

An astronaut. It was the mid '90s and Helen Sharman was living my dream.

Your book debunks myths about drugs. Why did you decide to write it?

Loads of us hold misconceptions about drugs, including legal ones like alcohol. I made a podcast exploring these, and the science around drugs more generally, and it really took off. The book explores what we know, and what we don't, about the drugs in our lives and in our societies.

What are the most common misconceptions about drugs?

One is that you only need to use a drug like heroin once to become addicted to it. Another is that legal drugs are less harmful. While it is true that there are additional risks when a substance is illicit, such as dosing, drugs like alcohol and tobacco are most certainly not without harm. Quite the opposite.

What's the most exciting thing you're working on right now?

I'm really excited about a current project using two groups of young people born 10 years apart to explore changing patterns in lifestyle behaviours and mental health in UK teenagers. Depression is on the rise in UK teens. We're trying to understand why, and hopefully do more to support young people.

How has your field of study changed in the time you have been working in it?

The national, and global, conversation about drugs is changing. We are seeing cannabis decriminalised in lots of places and it feels like the public perception of drugs has become a bit more nuanced.

Were you good at science at school?

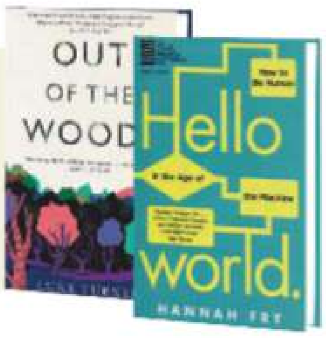
Yes, but if anything, it was A level English literature that helped the most for a degree in psychology.

What is the best piece of advice anyone ever gave you?

God damn it, you've got to be kind.

What's the best thing you've read or seen in the past 12 months?

Hannah Fry's *Hello World*, about algorithms, and Luke Turner's memoir *Out of the Woods*, exploring sexuality and Epping Forest, among other things.



Do you have an unexpected hobby, and if so, please will you tell us about it?

I play synths and have been in a number of bands, including a covers band that played the music of Goblin, a 1970s Italian horror soundtrack band.

If you could have a conversation with any scientist, living or dead, who would it be?

Elizabeth Blackwell, the first woman to get a medical degree in the US. She did so after a female friend said she might have suffered less with a recent illness if a female physician had treated her.

> "One of the most common misconceptions is that you only need to take a drug like heroin once to become addicted"

What scientific development do you hope to see in your lifetime?

A better understanding and treatment for dementia.

How useful will your skills be after the apocalypse?

I can knit, and I am quite good at growing vegetables.

OK, one last thing: tell us something that will blow our minds...

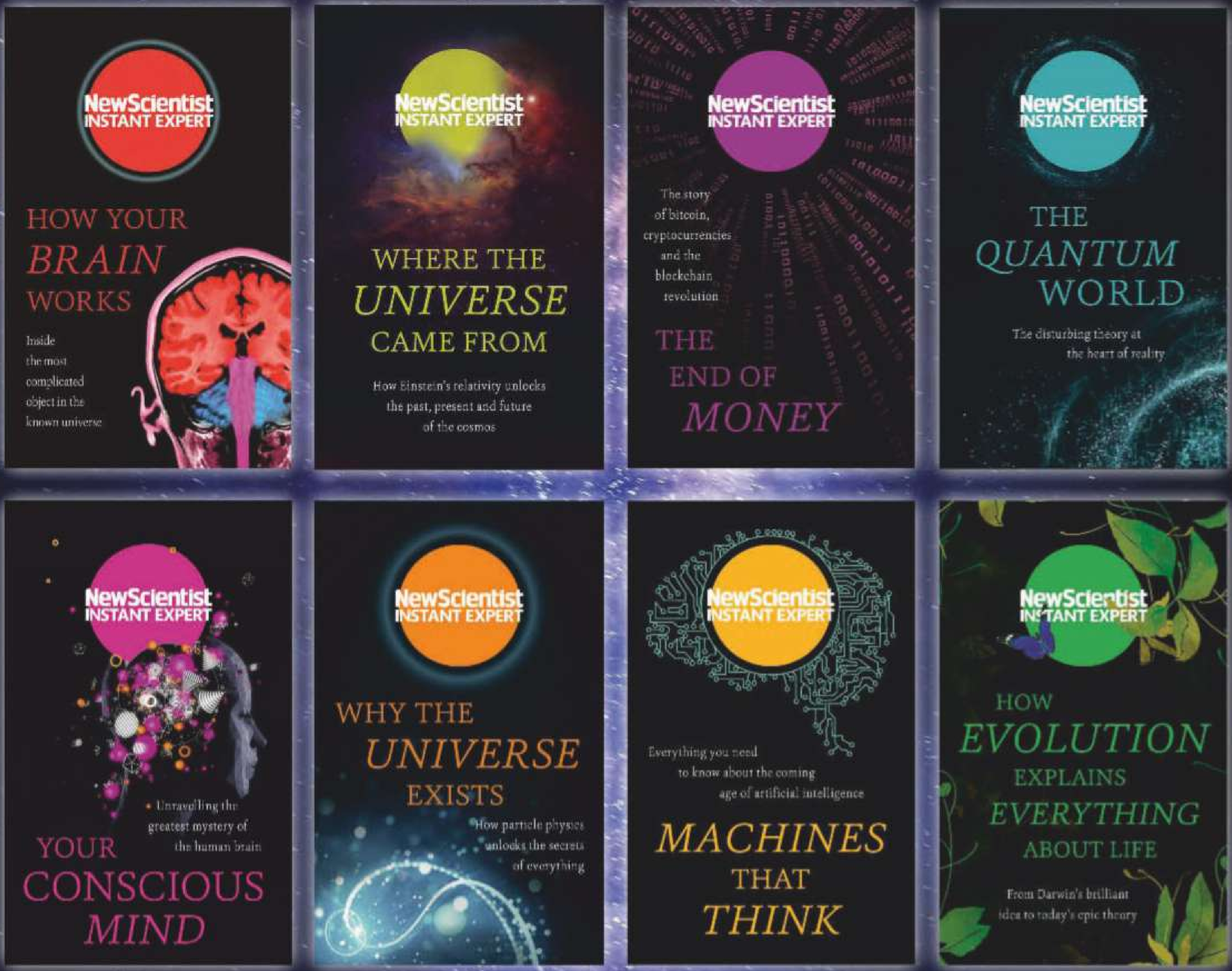
The drug ketamine really is a horse tranquilliser, but it is also particularly useful in camel surgery. ▮

Suzi Gage is a psychologist and epidemiologist at the University of Liverpool, UK. Her book *Say Why to Drugs* is out now (Hodder and Stoughton) @soozaphone

PORTRAIT: JIM MORAY

INTRODUCING THE
New Scientist
INSTANT EXPERT SERIES

DEFINITIVE, ENGAGING AND ACCESSIBLE GUIDES TO THE MOST IMPORTANT SUBJECTS IN SCIENCE.


NewScientist INSTANT EXPERT
HOW YOUR BRAIN WORKS
Inside the most complicated object in the known universe
NewScientist INSTANT EXPERT
WHERE THE UNIVERSE CAME FROM
How Einstein's relativity unlocks the past, present and future of the cosmos
NewScientist INSTANT EXPERT
The story of bitcoin, cryptocurrencies and the blockchain revolution
THE END OF MONEY
NewScientist INSTANT EXPERT
THE QUANTUM WORLD
The disturbing theory at the heart of reality
NewScientist INSTANT EXPERT
Unravelling the greatest mystery of the human brain
YOUR CONSCIOUS MIND
NewScientist INSTANT EXPERT
WHY THE UNIVERSE EXISTS
How particle physics unlocks the secrets of everything
NewScientist INSTANT EXPERT
Everything you need to know about the coming age of artificial intelligence
MACHINES THAT THINK
NewScientist INSTANT EXPERT
HOW EVOLUTION EXPLAINS EVERYTHING ABOUT LIFE
From Darwin's brilliant idea to today's epic theory

NewScientist newscientist.com/instant-expert-books